A review of the Euplotidae (Hypotrichida, Ciliophora)

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Introduction

Guides to the species of two genera of Euplotid ciliates, *Euplotes* Ehrenberg *in* Hemprich and Ehrenberg, 1831 and *Aspidisca* Ehrenberg, 1830, have been published in recent years (Curds, 1975; Wu & Curds, 1979). The other genera in the family Euplotidae Ehrenberg, 1838 contain fewer species but there are still identification problems in some. The present work is intended to aid the specific identification of the remaining nine genera which Borror (1972) grouped together into the Euplotidae, another more recently described genus and one other addition. Although four of these genera only contain single species it was thought worthwhile to include them for completeness. The genera included here are in chronological order of authority. *Discocephalus* Ehrenberg *in* Hemprich and Ehrenberg, 1828; *Diophrys* Dujardin, 1841; *Uronychia* Stein, 1859; *Certesia* Fabre-Domergue, 1885; *Gastrocirrhus* Lepsi, 1928; *Euplotaspis* Chatton and Séguéla, 1936; *Euplotidium* Noland, 1937; *Paraeuplotes* Wichterman, 1942; *Swedmarkia* Dragesco, 1954; *Gruberella* Corliss, 1960 and *Cyatharoides* Tuffrau, 1975.

Members of the Euplotidae are hypotrichs with the characteristically prominent adoral zone of membranelles (AZM) arranged at the anterior left of the ventral surface bordering a wide peristome. In certain genera the AZM may continue over the apical end of the body onto the dorsal surface. Unfortunately there is no set of characters which will include all of Borror's (1972) genera into the family. This could well indicate that it is not a natural family. The cirri on the ventral surface are arranged in distinct groups but they are not the only hypotrichs to have this feature. For example, the Oxytrichidae Ehrenberg, 1838 also have grouped cirri, and Borror (1972) distinguished them from the Euplotidae by their possession of only a few left marginal and no right marginal cirri, even so there are several exceptions to

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this rule. Furthermore, while right caudal cirri are present in *Diophrys*, *Discocephalus*, *Euplotes* and *Uronychia*, they are absent in others. However, transverse cirri are present in all but one Euplotid genus. With this state of affairs, perhaps it is not surprising that there is some disagreement in the literature as to what constitutes the family Euplotidae. Borror (1972) included Aspidisca in the family but Stein (1859*a*), Bütschli (1889), Kahl (1932), Fauré-Fremiet (1961) and Corliss (1961, 1977, 1979) all maintain it in a separate family the Aspidiscidae Ehrenberg, 1838. Corliss (1979) included four genera in the family Aspidiscidae; *Aspidisca*, *Euplotaspis*, *Onychaspis* Stein, 1859 and *Paraeuplotes* (as an *incertae sedis*). The genus *Onychaspis* differs from *Aspidisca* only by the former's possession of a larger number of transverse cirri and most authors consider it to be a synonym of *Aspidisca* (Borror, 1972; Wu and Curds, 1979). Indeed, Corliss (1979) indicated this possibility in his classification. One of the features of the Aspidiscidae is the great reduction of oral membranelles, however this description would not fit the AZM of *Euplotaspis* or *Paraeuplotes*. Corliss (1979) also placed three of the genera being considered here (*Cirrhogaster* Ozaki and Yagui, 1941; *Euplotidium* and *Gastrocirrhus*) into the family Gastrocirrhidae Fauré-Fremiet, 1961. Here the single species genus *Cirrhogaster* is regarded as a member of the genus *Gastrocirrhus* as it only differs slightly in cirral number. Borror (1972) included *Gastrocirrhus* in the Euplotidae but noted that its position in that family was provisional.

It is clear from this brief synopsis that the position of these genera within three or a single family group is still in a state of flux and to a large extent a matter of conjecture. It is not the purpose of the present paper to attempt to assign the genera to any old, current or new classification scheme; more data, particularly concerning their comparative morphogenesis, are required before anything useful can be suggested. The aim here is to aid the marine ecologist and protozoologist to identify the species of those genera which conveniently fall within the single family Euplotidae.

Key to Genera

1	AZM conspicuous, in single anterior part	2
	AZM inconspicuous, in 2 parts	***ASPIDISCA*** (see Wu & Curds, 1979)
2	Without frontoventral cirri, caudals never extremely large	***GRUBERELLA*** (p. 242)
	With frontoventral cirri (when frontoventrals reduced and inconspicuous then caudals usually very large)	3
3	With caudal cirri	4
	Without caudal cirri	11
4	With marginal cirri, caudals sometimes very large	5
	Without marginals, caudals present but never very large	7
5	Caudals very large and prominent	6
	Caudals weak	***EUPLOTES*** (see Curds, 1975)
6	5 – 10 conspicuous frontoventral cirri present, moves forwards	***DIOPHRYS*** (p. 197)
	3 inconspicuous cirri present, moves backwards	***URONYCHIA*** (p. 215)
7	Elongate with discoid 'head' region	***DISCOCEPHALUS*** (p. 193)
	Ovoid to elongate, when elongate never with discoid 'head' region	8
8	Ovoid, dorsoventrally flattened	9
	Elongate, rounded in section, often cup-shaped with funnel-shaped peristome opening apically and ventrally	10
9	Cirri mainly in 2 rows, found on coral	***PARAEUPLOTES*** (p. 239)
	Cirri in well-defined groups, found in sea-squirts	***EUPLOTASPIS*** (p. 232)
10	With 5–6 transverse cirri	***EUPLOTIDIUM*** (p. 234)
	Without transverse cirri	***GASTROCIRRHUS*** (p. 228)
11	Without marginal cirri, rounded in section	***EUPLOTIDIUM*** (p. 234)
	With marginal cirri, dorsoventrally flattened	12
12	Marginal cirri on both right and left sides, confluent posteriorly	***SWEDMARKIA*** (p. 240)
	Marginal cirri on either right or left sides	13
13	Marginal cirri on left, not planktonic	***CERTESIA*** (p. 227)
	Marginal cirri on right, planktonic	***CYATHAROIDES*** (p. 243)

Genus *DISCOCEPHALUS* Ehrenberg, 1828

Introduction

The genus *Discocephalus* was erected by Ehrenberg *in* Hemprich and Ehrenberg (1828) and although his description and illustration of the type species *D. rotatorius* were crude, it was clear that the organism had a distinctive discoid 'head' formed by a constriction at the anterior end of the elongate oval body. Bütschli (1889) expressed some doubt concerning the observations of Ehrenberg (1831) but it was not until Kahl (1932), that *Discocephalus* was adequately described. The latter description concerned an organism which Kahl (1932) considered to be *D. rotatorius* Ehrenberg and of which he thought *Polycoccon octangularis* Sauerbrey, 1928 to be a junior synonym. Later, however, Dragesco (1960) isolated an organism from Roscoff which although identical to that described by Kahl (1932) was different in several respects from *D. rotatorius* Ehrenberg. Dragesco (1960) therefore named the species found at Roscoff *D. ehrenbergi* and designated *D. rotatorius* Kahl to be its junior synonym. However, Dragesco (1960) agreed that *Polycoccon octangularis* Sauerbrey was a synonym of *D. rotatorius* Ehrenberg. In addition to the two species mentioned above two others, *D. grandis* Dragesco, 1954 and *D. minimus* Dragesco, 1968, have been described.

There is a well developed AZM in all four of the above species which borders the small ventral peristome on the left of the discoid 'head'. In one species, *D. ehrenbergi*, there are 5–7 large membranelle-like structures lying along the right border of the peristome which Dragesco (1968) called 'pre-membranelles'. This character enables the diagnosis and separation of *D. ehrenbergi* Dragesco from *D. rotatorius* Ehrenberg which lacks these 'membranelles'.

The cirral patterns on the ventral surface of *Discocephalus* differ greatly from those of *Euplotes* and as their morphogenesis is yet to be published fully it is difficult to interpret them adequately. Furthermore as the cirri vary considerably from species to species, it is possible that *Discocephalus* is really a polyphyletic group. The present confusion in different terms used for the same cirri by different authors can be illustrated by reference to 'marginal' cirri. In *D. rotatorius* and *D. ehrenbergi* there are two 'marginal' cirri on the left body edge just below the peristome. However, in *D. grandis*, Dragesco (1954) refers to the presence of three rows of 'marginal' cirri which is more characteristic of members of the Oxytrichidae rather than the Euplotidae. Furthermore, in *D. minimus* there is one row of cirri on the right body edge called ventral cirri and one row on the left edge called 'marginal' cirri. Until further morphogenetic information becomes available the present authors prefer to follow in part the system used by Hartwig and Parker (1977) which distinguishes left, central and right ventral cirri rather than to attempt to distinguish marginal from ventral rows simply on the basis of their position on the ventral surface. However, it is preferable to call the most posterior cirri, left and right caudal cirri, rather than left and right posterior 'marginals' as used in Hartwig and Parker (1977). The dorsal surface of *Discocephalus* has received less attention than that of either *Euplotes* (Curds, 1975) or *Aspidisca* (Wu & Curds, 1979) but both Dragesco (1965) and Kahl (1932) have illustrated *D. ehrenbergi* with six kineties on the dorsal surface. Dorsal argyrome patterns as found in *Euplotes* and *Aspidisca* (Curds, 1975: Wu & Curds, 1979) have yet to be described. This means that the four species must currently be distinguished on the basis of their size, numbers and distribution of cirri, the presence or absence of membrane-like structures on the right of the peristome and the nature of the macronuclear apparatus. Corliss (1979) described this as a curious genus which he included only 'tentatively' in the Euplotidae and indeed, the unique body shape, the cirral arrangement and large number of macronuclear parts may well be considered sufficient for placing it in a separate family.

Diagnosis of *Discocephalus*

Oval marine hypotrichs with an anterior constriction of the body which forms a discoid

'head' containing the peristome and AZM on the left. Ventrally there are 4–8 frontal, 5–11 transverse (including satellites) and variable numbers and arrangements of ventral cirri. Posterio–dorsally there are 3–4 right caudal and 9–30 left caudal cirri. The size varies between 50–200 μm long and there are numerous macronuclei.

Key to the species of *Discocephalus*

1	With 2 left ventral cirri	2
	With 7 to many left ventral cirri	3
2	With 5 transverse cirri but without 'pre-membranelles'	***D. rotatorius***
	With 8–9 transverse cirri and several 'pre-membranelles'	***D. ehrenbergi***
3	Large (200 μm), row of many (about 40) left ventral cirri	***D. grandis***
	Small (50 μm), row of few (7–8) left ventral cirri	***D. minimus***

Species descriptions

Discocephalus rotatorius Ehrenberg, 1828 *in* Hemprich and Ehrenberg

Polycoccon octangulus Sauerbrey, 1928

DESCRIPTION (Fig. 1). Medium sized (70–100 μm long) marine species whose elongate, oval body is typically discocephalic. There is a well developed AZM bordering the left of the peristome area. The 7–8 frontal cirri are restricted to the anterior 'head' region. The ventral cirri are in two groups: there are 2–4 on the right body edge and 2 on the left immediately behind the peristome. There are 5 prominent transverse cirri. The caudal cirri are also in two groups and arise dorso-laterally: on the right are 3–4 large prominent caudals and on the left

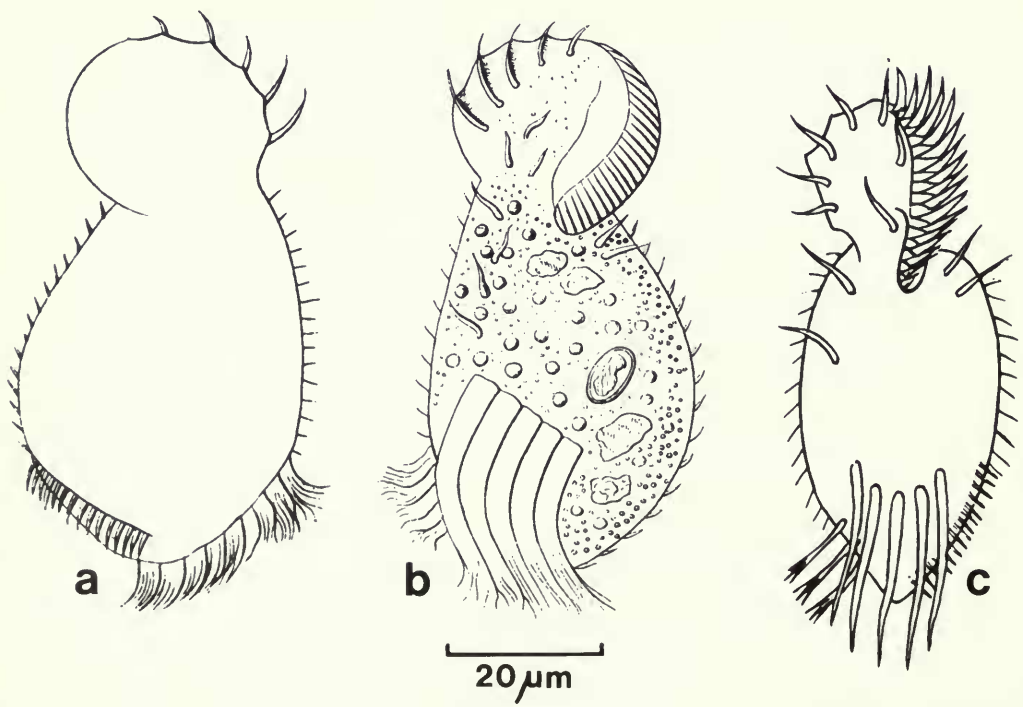

Fig. 1 *Discocephalus rotatorius*: (a, b) after Sauerbrey, 1928 (called *Polycoccon octangulus*); (c) unpublished figure after Fauré-Fremiet (in Dragesco, 1960).

is a row of many (12–20) smaller caudal cirri. The macronucleus is divided into many randomly distributed spherical parts.

NOTES. The description is based on that of Sauerbrey (1928) and on the illustration given in Dragesco (1960) but attributed to unpublished diagrams of Fauré-Fremiet.

Discocephalus grandis Dragesco, 1954

DESCRIPTION (Fig. 2). Large (200 μm long) marine species with an uncharacteristically large number (120–150) of ventral cirri arranged in three longitudinal rows: one lies on the left body edge and two on the right. There are 4 frontal cirri which are all located along the right margin of the discoid 'head'. Immediately above the first of the long transverse cirri, on the left, are two small 'satellite' transversal cirri. There are two small right caudal and about 13 left caudal cirri. The macronucleus is divided into many (10–20) spherical parts each being 3–6 μm in diameter.

NOTE. This description is based on those of Dragesco (1954, 1960) who noted that the species is very similar to *Holosticha discocephalus* Kahl.

Discocephalus ehrenbergi Dragesco, 1960

Discocephalus rotatorius Kahl, 1932 misidentification

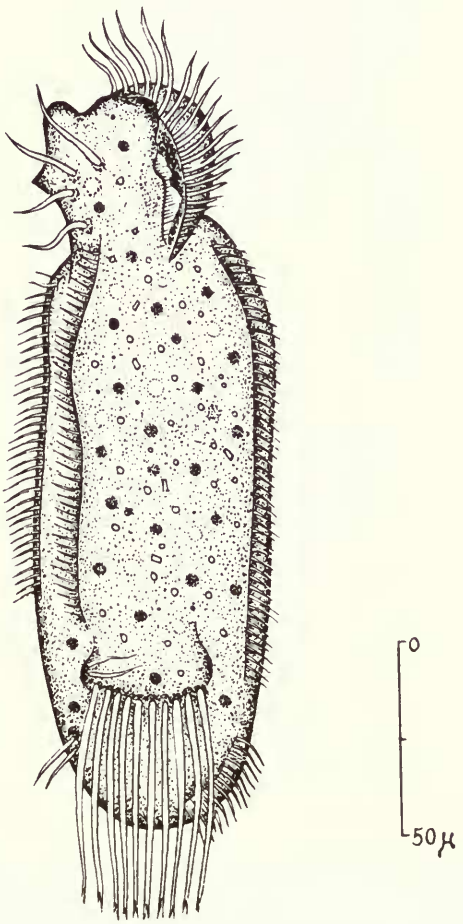

Fig. 2 *Discocephalus grandis*, after Dragesco, 1960.

DESCRIPTION (Fig. 3). This is a medium sized (90–120 μm long) marine species. The presence of 7–9 transverse cirri (with 1 or 2 'satellites', Fig. 3f–h) and 5–7 'pre-membranelles' on the right of the peristome serve to distinguish it from the type species *D. rotatorius* Ehrenberg. The AZM consists of 18–22 membranelles arranged along the left of the peristome and there is an undulating membrane on the right. The 4–8 frontal cirri are of variable size and there are 2 left ventral, 2 mid-ventral and 4 right ventral cirri. The caudal cirri are in two groups: 3–4 right caudal and 14–20 caudal cirri on the left. There are 6 dorsal kineties with only the third from the right extending into the 'head' region (Dragesco, 1965). There is a large

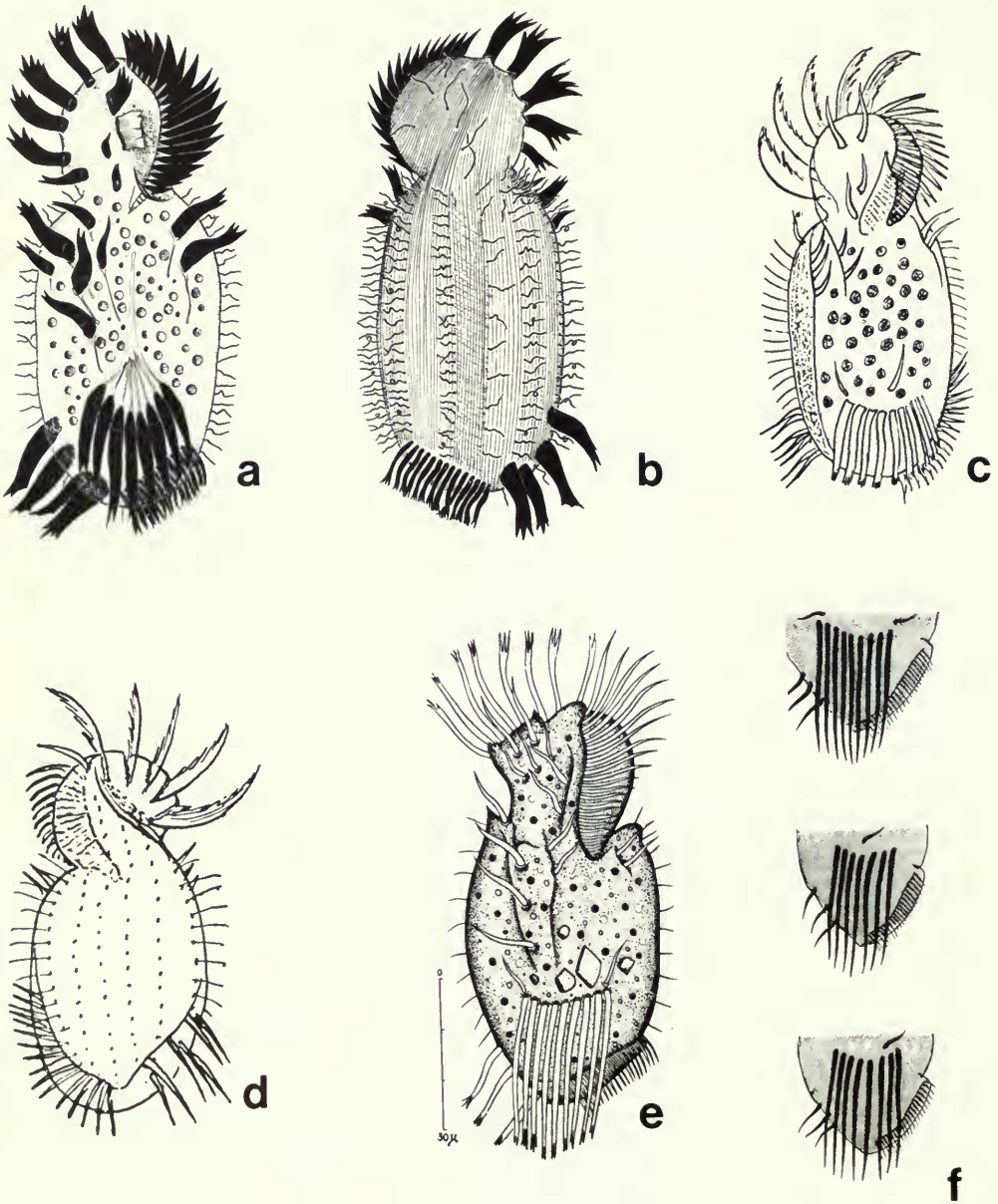

Fig. 3 *Discocephalus ehrenbergi*: (a, b) ventral and dorsal surfaces, after Dragesco, 1965; (c, d) ventral and dorsal surfaces, after Kahl, 1932 (called *D. rotatorius*); (e, f) ventral surface and variations in transverse cirral arrangement, after Dragesco, 1960.

number of spherical parts to the macronuclear apparatus which are scattered throughout the body but apparently not in the 'head' region.

NOTES. This species was first described by Kahl (1932) as *D. rotatorius* Ehrenberg but was renamed and redescribed by Dragesco (1960, 1965). Later Dragesco (1968) expressed doubts about his conclusions and suggested that the species described as *D. ehrenbergi* in 1960 (Fig. 3e–h) might be a different species from that described in 1965 (Fig. 3a–b), although there was insufficient information to be certain. The description above is based on that of Dragesco (1965) but variations noted in other descriptions are included.

Discocephalus minimus Dragesco, 1968

DESCRIPTION. *Discocephalus minimus* (Fig. 4) is characterised by its small size (50–60 μm long) and possession of left ventral cirri. The species has 7 frontal, 4–6 right ventral, 2 mid-ventral and 7 left ventral cirri. There are 4 right caudal and 9–10 left caudal cirri. The macronucleus is divided into relatively few (3–15) spherical parts.

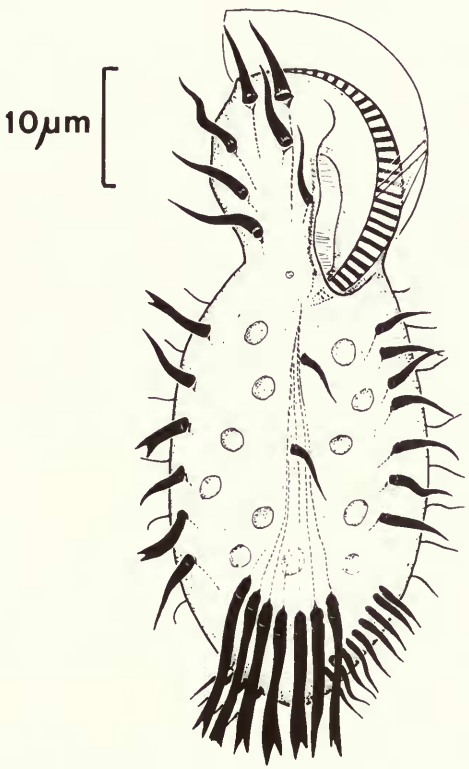

Fig. 4 *Discocephalus minimus*, after Dragesco, 1968.

NOTES. The single description of this species is based on the observation of 5 individuals (Dragesco, 1968) and there are no data on the dorsal aspect of this organism.

Genus ***DIOPHRYS*** Dujardin, 1841

Introduction

It was Dujardin (1841) who first briefly described an organism called *Diophrys marina* and defined the genus *Diophrys* as having a discoid shape with groups of long 'cilia' at the two extremities of the body which was without a mouth. Later Stein (1859*a*) stated that both *D. marina* and the earlier *Stylonychia appendiculata* Ehrenberg, 1838 were synonyms of

Styloplotes appendiculatus Stein, 1859 (see Stein 1859*a*) which he characterised by the presence of three large right caudal cirri. Bütschli (1889) recognised *Diophrys* as a distinct genus and his list of synonyms included certain species of the genera, *Stylonychia* Ehrenberg, *Ploesconia* Dujardin, *Euplotes* Claparède & Lachmann, *Schizopus* Claparède & Lachmann, *Styloplotes* Stein, *Styloplotes* Quennestedt, *Styloplotes* Fresenius, *Styloplotes* Rees, *Styloplotes* Fabre-Domergue, and *Styloplotes* Andrusova. Although Bütschli (1889) stated that there were two species in the genus, he only illustrated *Diophrys* (*Styloplotes*) *grandis* Rees, 1881 and failed to mention *D. appendiculata*. Over the next few years the combination *D. appendiculata* was used occasionally, for example, by Wallengren (1901) and by Calkins (1902) who established the combination *Diophrys* (*Styloplotes*) *appendiculatus* Stein. However, it was Kahl (1932) who first traced the taxonomic history of the species correctly. Borror (1972) recently listed eleven species of the genus with their synonyms and he designated *Diophrys scutum* (Dujardin, 1841) Kahl, 1932 the type species and listed *D. marina* as a synonym of *D. appendiculata* (Ehrenberg) Kahl. In view of the evidence given above, the present authors are of the opinion that *Diophrys* (*Stylonychia*) *appendiculata* (Ehrenberg, 1838) Kahl, 1932 is the correct name and authority for the type species of the genus *Diophrys*.

Kahl (1932) defined the genus *Diophrys* as those members of the family Euplotidae with conspicuous sturdy transverse cirri and a single group of three large caudal cirri. In addition to *D. appendiculata*, Kahl (1932) described, and gave keys, to three other species, *Diophrys* (*Ploesconia*) *scutum* (Dujardin, 1841) Kahl, 1932; *Diophrys hystrix* Buddenbrock 1920 and *Diophrys irmgard* Mansfeld, 1923. Of the eleven species listed by Borror (1972) the present authors accept ten nominal species. *D. tetramacronucleata* Kattar, 1970 and *D. multinucleata* Hartwig, 1973 are two later additions to the genus, characterised by their possession of four and over twenty macronuclei respectively. The authors accept the latter as a distinct species but suspect that the former is a synonym of *D. appendiculata*.

Two of the species, *D. appendiculata* and *D. scutum*, have been described by many authors over the past century but most of the other species are relatively recent additions. In most cases there are rather few data on the extent of intraspecific variation that might be found in potentially useful diagnostic structures. Even so, it was thought worthwhile to present a summary of the data that are available and to discuss the possible diagnostic importance of the various morphological features.

(*a*) *Shape*. The typical body shape of *Diophrys* is an ovoid in which there is often a posterior right lateral indentation where the right caudal cirri are located. The anterior of *D. hystrix* is particularly truncate and the body of *D. kahli* is elongate. The dorsal surface of *Diophrys* is generally smooth, but in *D. irmgard* it is described with a 'trapeziform elevation' (Mansfeld, 1923). These variations are apparently distinctive although the keys here do not rely upon them for identification of these species.

(*b*) *Size*. Most *Diophrys* species are between 50 and 120 μm long. *D. scutum* at 150–200 μm long is the largest and *D. hystrix* at 30–40 μm long is the smallest. Size variation within species appears to be small (Hartwig, 1973) so the size differences between *D. hystrix*, *D. scutum* and *D. appendiculata* (50–100 μm long) are likely to be of diagnostic value.

(*c*) *Adoral zone of membranelles (AZM)*. *Diophrys* has a wide peristome which extends a third to two-thirds down the body length. On the right of the peristome there is a large, wide undulating membrane. On the left, there is a well-developed AZM which continues anteriorly over onto the dorsal surface: in some species it can return to the ventral surface down the right side of the body. Borror (1965*a*) stated that statistical analysis showed that the length of the right portion of the AZM in *D. scutum* was significantly longer from that of *D. peloetes*. He noted that this 'terminal portion' of the AZM in *D. scutum* was 0·4 the body length but only 0·3 the body length in *D. peloetes*. The present authors would not recommend species recognition on such a small difference as this without resort to statistical morphometric analysis but it is a useful feature for distinguishing between certain species.

For example, in *D. appendiculata* the AZM hardly extends onto the right of the body while in *D. scutum* it extends almost to the central region. Rees (1883) and Kahl (1932) also consider this right extension of the AZM to be an important diagnostic feature by which they identified *Styloplotes quennerstedti* and *D. scutum* respectively.

(*d*) *Cirri.* The type species, *D. appendiculata*, has 7–8 frontoventral, 5 transverse, 1–3 left marginal and 3 right caudal cirri. The frontoventral cirri are arranged in two distinct groups, with 5 in the anterior right frontal group and 2–3 in the ventral group, often much smaller than the frontal cirri, lying in close proximity to the first transverse cirrus on the right. This distribution pattern is seen in all species but *D. hystrix*, *D. irmgard* and *D. kahli* have 9–10 frontoventrals in groups of 7 frontals and 2–3 ventrals which the authors consider to be of diagnostic importance. Some authors are in agreement with this others are not. For example, Agamaliev (1967) established a new species *D. scutoides* which differs from *D. scutum* only in having five instead of seven frontoventral cirri. However, Borror (1963) identified an organism as *D. irmgard* even though it possessed only five frontoventrals rather than the nine in Mansfeld's (1923) original description. Borror (1963) neither established the organism as a new species nor did he suggest the cirral difference to be due to intraspecific variation. The morphogenesis of cirri in *D. appendiculata* was described by Wallengren (1901). The frontoventral-transverse cirri arise from six streaks of kinetosomes as in *Euplotes*, with the I/1, II/2, II/3, III/2 and IV/2 cirri forming the frontals: V/2 and VI/2 the ventrals and II–VI/1 the transversals (Fig. 5).

The transverse cirri of *Diophrys* are noticeably larger than those of *Euplotes*. There are almost invariably five transverse cirri but there are only four in *D. irmgard* and *D. multinucleata*. The presence of large, sickle-shaped, dorso-laterally attached right caudal cirri is a characteristic feature of the genus *Diophrys*. During morphogenesis, these cirri arise from basal bodies at the posterior ends of the ciliary rows on the right of the dorsal surface (Borror, 1972). Most of the species described have three of these cirri but *D. quadricaudatus* Agamaliev, 1967 has four and *D. kahli* Dragesco, 1963 has only one. Intraspecific variation in the number of these cirri has not yet been reported and so it is thought that this might be a useful diagnostic character. In most species, the left marginal cirri are located just posterior

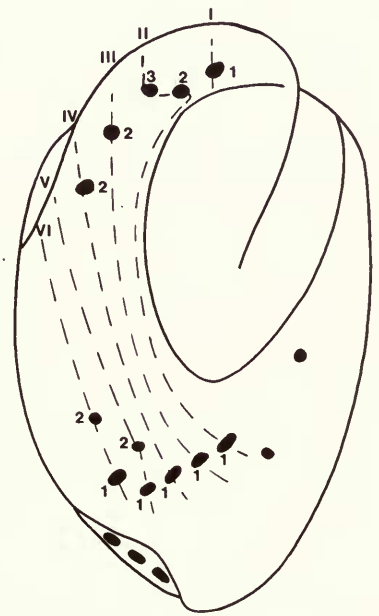

Fig. 5 Arrangement and numbering of cirral streaks in *Diophrys appendiculata*, after Wallengren, 1901.

to the peristome, but in *D. irmgard*, *D. kahli* and *D. multimicronucleata*, they are in the 'caudal position' as are those in *Euplotes* and *Uronychia*. Hartwig (1974) believed that the positioning of these cirri in these three species was sufficient to constitute a separate genus. While the present authors agree that the caudal positioning of the left marginal cirri appears to be a significant character apparently associated with the presence of only four transverse cirri, they hesitate to erect a new genus on this alone. Mansfeld (1923) and Kahl (1932) distinguished *D. irmgard* from other species, not by the position of the left marginal cirri but by their number. Although most species have two left marginal cirri and *D. irmgard* has three, variation between 1–3 has been observed in *D. appendiculata*.

(*e*) *Nuclear features*. The most commonly found nuclear arrangement in *Diophrys* is two macronuclei and 2–6 micronuclei. Exceptions to this include *D. quadricaudatus*, *D. tetramacronucleata* and *D. multinucleata* which have three, four and over 20 macronuclei respectively, with the diagnosis of the latter two species resting heavily on this feature. The macronuclei may be rod-shaped, ovoid or moniliform.

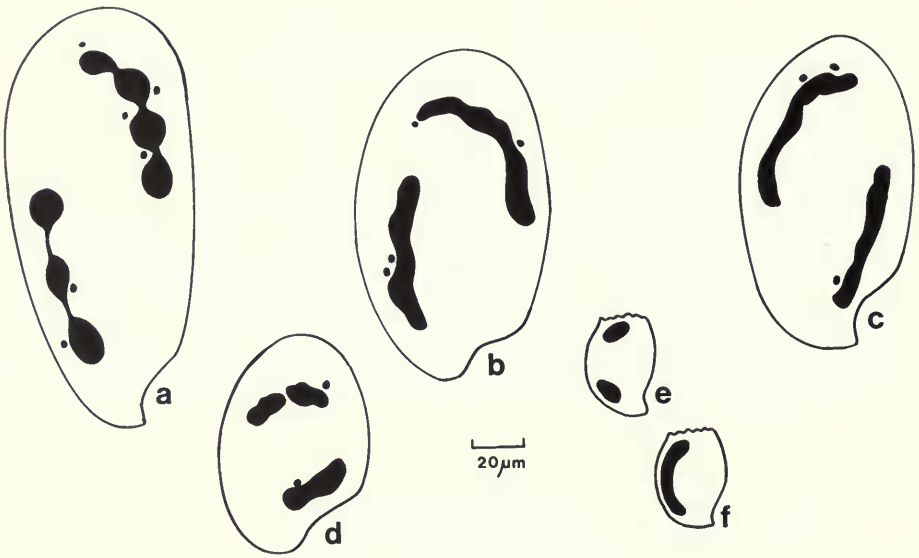

Fig. 6 Nuclear arrangement in *Diophrys*: (a) *Diophrys magnus*, after Raikov & Kovaleva, 1968; (b–d) *Diophrys scutoides*, after Agamaliev, 1967; (c) *Diophrys quadricaudatus*, after Agamaliev, 1967; (e, f) *Diophrys hystrix*, after Buddenbrock, 1920.

Raikov and Kovaleva (1968) separated *D. magnus* from *D. scutum* principally on the basis of its macronuclei being moniliform, however they are similar to those of *D. scutum* and other species which are often shown to be slightly nodular (Fig. 6a–c). Here *D. magnus* and *D. scutum* are therefore regarded to be synonymous.

Summers (1935) described the reorganisation and division of the macronuclei of *D. scutum*, misidentified as *D. appendiculata*. He noted (Fig. 7) that in the normal resting stage, the species possesses two macronuclei without a visible strand between them and a variable number of micronuclei. He observed that fragmentation of the reorganised parts of the macronuclei was not uncommon but 'fragments of the macronuclei have never been found free in the cytoplasm after the several parts fuse to form the rod-like mass'. One cannot be certain if the tripartite macronuclear structure of *D. quadricaudatus* (Fig. 6d) is the result of fragmentation or if it is the true resting stage, but it is likely that the sausage-shaped nucleus which Buddenbrock (1920) described in certain specimens of *D. hystrix* to be a divisional stage in the normally ovoid macronuclei (Fig. 6e).

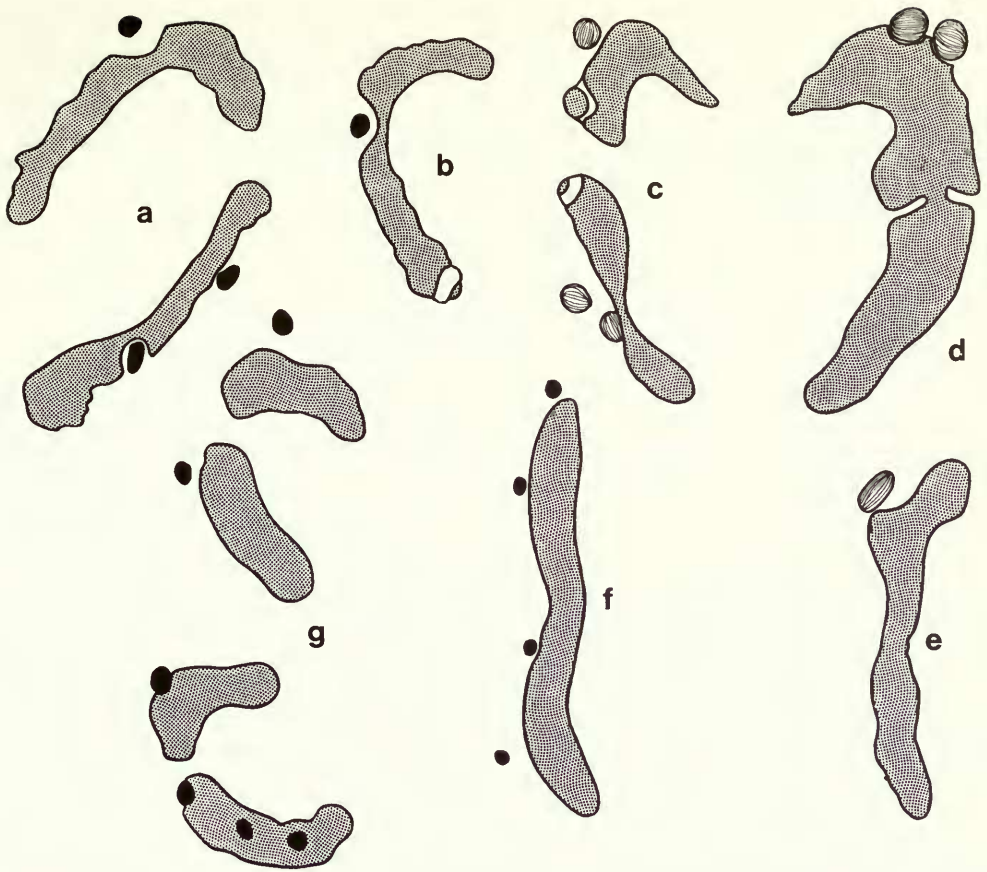

Fig. 7 Division of the macronucleus of *Diophrys scutum*, after Summers, 1935 (called *D. appendiculata*): (a) nucleus at rest; (b) first appearance of a reorganisation band at the outer pole of the posterior macronucleus; (c) reorganisation bands about to disappear at inner poles of the macronuclei; (d) fusion of the macronuclei; (e) after fusion; (f) macronucleus beginning to divide; (g) macronuclei completely divided just before daughter cells separate.

Kisselbach (1936) also illustrated various stages in the nuclear development of *D. appendiculata* (Fig. 8a–e) one of which shows a quadripartite stage similar to that illustrated by Kattar (1970) in *D. tetramacronucleata* (Fig. 8f, g). In view of this *D. tetramacronucleata* should be strongly suspected as being a synonym of the type species. However, since one illustration by Kattar (1970) and another by Hartwig (1974) show the four ovoid macronuclei to be completely distinct (Fig. 8g) the species has been provisionally included here awaiting further data. As mentioned above, there are commonly 2–6 micronuclei in *Diophrys*. Borror (1965*a*) accorded little significance to this feature and referred to Ito (1963) who stated that macronuclei may vary considerably in number within a species.

(*f*) *Dorsal silver-line system.* Borror (1965*a*) pointed out that few workers had mentioned the dorsal ciliature in *Diophrys* species descriptions and observed that Kahl (1932) was the first to note the presence of five rows of short cilia in *D. scutum*. Using the Chatton-Lwoff (1930) technique, Borror (1965*a*) was able to show that '. . . the kinetosomes in the dorsal rows of *Diophrys* behave during cell division in a manner similar to the behavior of the dorsal kinetosomes in *Euplotes*, hence the proter and opisthe usually have the same number of rows. Within a population, with practically no exceptions, all members of the genus present have the same number of rows of cilia dorsally, and this is apparently not related with body size.'

Several authors have used the number of dorsal kineties as a diagnostic character (Borror, 1965*a*, *b*: Agamaliev, 1967: Raikov & Kovaleva, 1968). However, the dorsal silver-line systems of other species including *D. hystrix*, *D. irmgard*, *D. kahli*, *D. tetramacronucleata* and *D. multinucleata* still remain to be described. For this reason the key here only distinguishes between *D. oligothrix* and *D. peloetes* on this character. All dorsal argyromes that have been described so far consist of a meshwork pattern and are therefore of little value for specific identification.

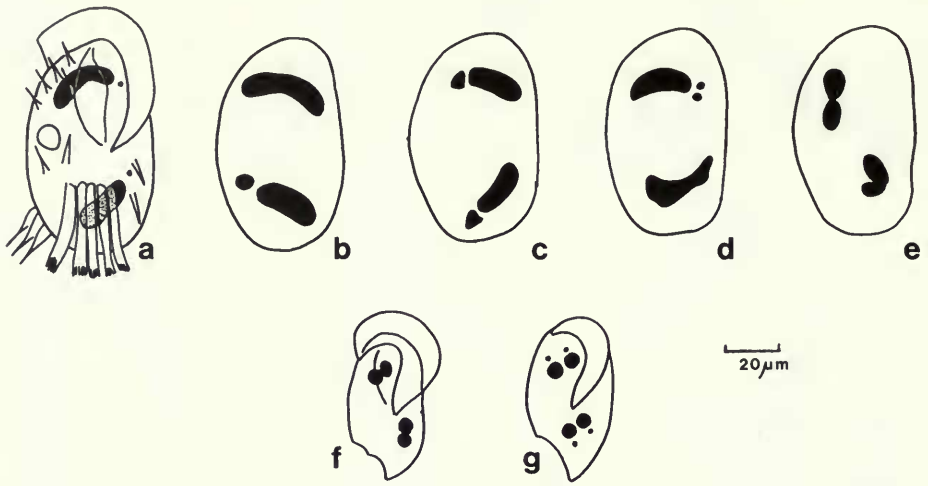

Fig. 8 Nuclear arrangement in *Diophrys*: (a–e) *Diophrys appendiculata*, after Kisselbach, 1936; (f, g) *Diophrys tetramacronucleata*, after Kattar, 1970.

Diagnosis of *Diophrys*

Marine hypotrichs 30–200 μm in length. Ovoid body usually with prominent right posterio-lateral concavity from which arise three large sickle-shaped right caudal cirri. There are 5–10 frontoventral, 4–6 transverse and usually 2–3 left marginal cirri. There are often two elongate, sometimes nodular, macronuclei but in some species there may be four or over twenty macronuclei. There is a variable number of micronuclei. The dorsal silver-line system consists of 4–8 dorsolateral kineties and a mesh-like argyrome.

Key to the species of *Diophrys*

1	With 5 frontoventral cirri	***D. scutoides***
	With more than 5 frontoventral cirri	2
2	With 7–8 frontoventral cirri	3
	With 9–10 frontoventral cirri	10
3	With 4 right caudal cirri	***D. quadricirratus***
	With 3 right caudal cirri	4
4	With 1–3 left marginal cirri	5
	Without left marginal cirri	***D. salina***
5	With 2 macronuclei	6
	With 4 or more macronuclei	9
6	With 5–6 dorsolateral kineties	7
	With less than 5 or greater than 6 dorsolateral kineties	8
7	AZM extends almost to centre of right border, 150–200 μm long.	***D. scutum***
	AZM hardly extends at all down right border, 50–100 μm long	***D. appendiculata***
8	With 4 dorsolateral kineties	***D. oligothrix***
	With 8 dorsolateral kineties	***D. peloetes***

9	With 4 macronuclei	*D. tetramacronucleata*
	With 20 or more macronuclei	*D. multinucleata*
10	With 2 left marginal cirri posterior to the peristome, 30–40 μm long	*D. hystrix*
	Left marginal cirri in the 'caudal' position, 80–100 μm long.	11
11	With 1 right caudal and 2 left marginal/caudal cirri	*D. kahli*
	With 3 right caudal and 3 left marginal/caudal cirri	*D. irmgard*

Species descriptions

Diophrys appendiculata (Ehrenberg, 1838) Kahl, 1932

Stylonychia appendiculata Ehrenberg, 1838
Diophrys marina Dujardin, 1841
Schizopus norwegicus Claparède & Lachmann, 1858
Styloplotes appendiculatus Stein, 1859
Styloplotes fresenii Rees, 1883
Styloplotes appendiculatus var. *pontica* Andrusova, 1886
Planiplotes wagneri Andrusova, 1886
Diophrys appendiculatus (Stein, 1859) Calkins, 1902

Description (Figs 9, 10). This, the type species of the genus, is 50–100 μm long. The body shape is typically ovoid with the characteristic lateral concavity at the posterior where the three sickle-shaped right caudal cirri arise. There are 7–8 frontoventral cirri – 5 anterior and 2–3 close to the transversals, 5 transverse and 1–3 left marginal cirri. The AZM extends down half to two-thirds of the length of the body on the left but hardly at all on the right. The two macronuclei are usually elongate to ovoid and may be smooth or nodular. There are 2–4 micronuclei and 5–6 dorsolateral kineties each carrying 6–10 cilia.

Notes. Some of the nomenclatural history of this species has already been outlined in the introduction to the genus. Kahl (1932) transferred *Stylonychia appendiculata* Ehrenberg, 1838 to the genus *Diophrys* and redescribed the species. However, he made no reference to the fact that Stein (1859*a*) had already erroneously redefined the species as *Styloplotes appendiculatus* which combination was subsequently used by many workers (Fresenius, 1865: Quennerstedt, 1867: Kent, 1881: Rees, 1883: Fabre-Domergue, 1885). Stein (1859*a*) suggested that Ehrenberg (1838) had overlooked the frontoventral cirri and suggested that *Schizopus norwegicus* Claparède & Lachmann, 1858 was probably a synonym, even though Claparède & Lachmann (1858) had distinguished their species from *Stylonychia appendiculata* Ehrenberg by the absence of marginal cirri. It seems likely that the two left marginal cirri were mistaken identified to be satellite transverse cirri. Calkins (1902) later transferred *Styloplotes appendiculatus* Stein to the genus *Diophrys*.

Rees (1883) briefly described a species of *Styloplotes* which he stated was the same as *Styloplotes appendiculatus* Stein as described by Fresenius (1865) which he (Rees, 1883) proceeded to call *Styloplotes fresenii*. Earlier Rees (1881) had described the new species *Styloplotes grandis* but later (Rees, 1883) concluded that it was identical to *Styloplotes norwegicus* Quennerstedt, 1867 which he then erroneously called *Styloplotes quennerstedti*. In the present authors, opinion, Quennerstedt (1867) was mistaken in making *Styloplotes norwegicus* Quennerstedt a synonym of *Schizopus norwegicus* Claparède & Lachmann. It is here considered that the former species is a synonym of *D. scutum* because of the extent to which the AZM is developed on the right side of the body. Rees (1883) also used this character to distinguish *Styloplotes quennerstedti*, a synonym of *D. scutum*, from *Styloplotes fresnii*, a synonym of *D. appendiculata*.

Diophrys scutum (Dujardin, 1841) Kahl, 1932

Ploesconia scutum Dujardin, 1841 (in part)

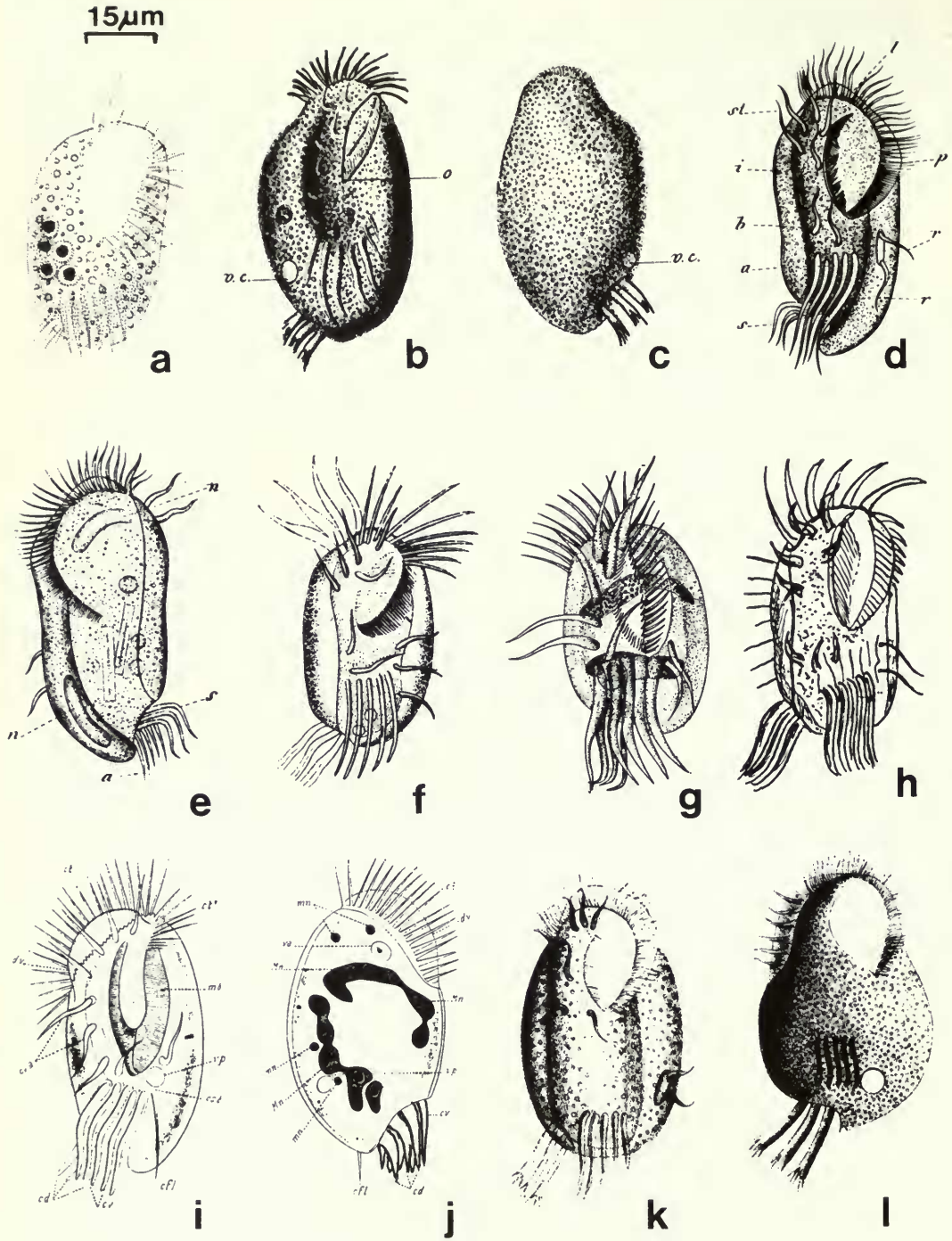

Fig. 9 *Diophrys appendiculata*: (a) after Ehrenberg, 1838 (called *Stylonychia appendiculata*); (b, c) after Claparède & Lachmann, 1858 (called *Schizopus norwegicus*); (d, e) after Stein, 1859*a* (called *Styloplotes appendiculatus*); (f) after Fresenius, 1865 (called *Styloplotes appendiculatus*); (g) after Calkins, 1902 (called *D. appendiculatus*; (h) after Kahl, 1932; (i, j) after Pierantoni, 1909; (k) after Andrusova, 1886 (called *Styloplotes appendiculatus* var. *pontica*; (l) after Andrusova, 1886 (called *Planiplotes wagneri*).

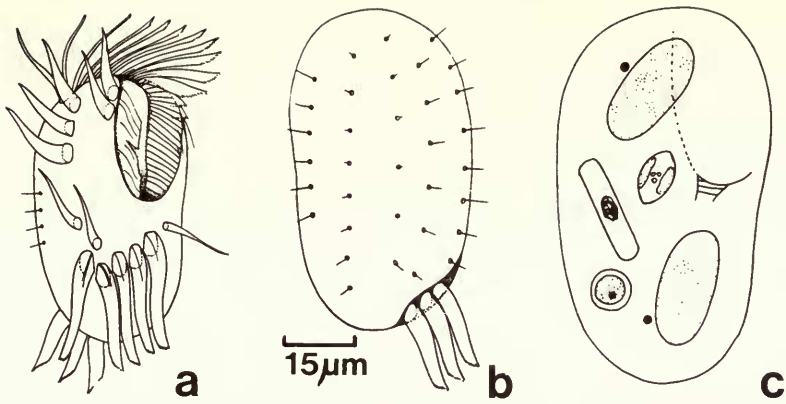

Fig. 10 *Diophrys appendiculata*, after Borror, 1963: (a) ventral surface; (b) dorsal surface; (c) nuclei.

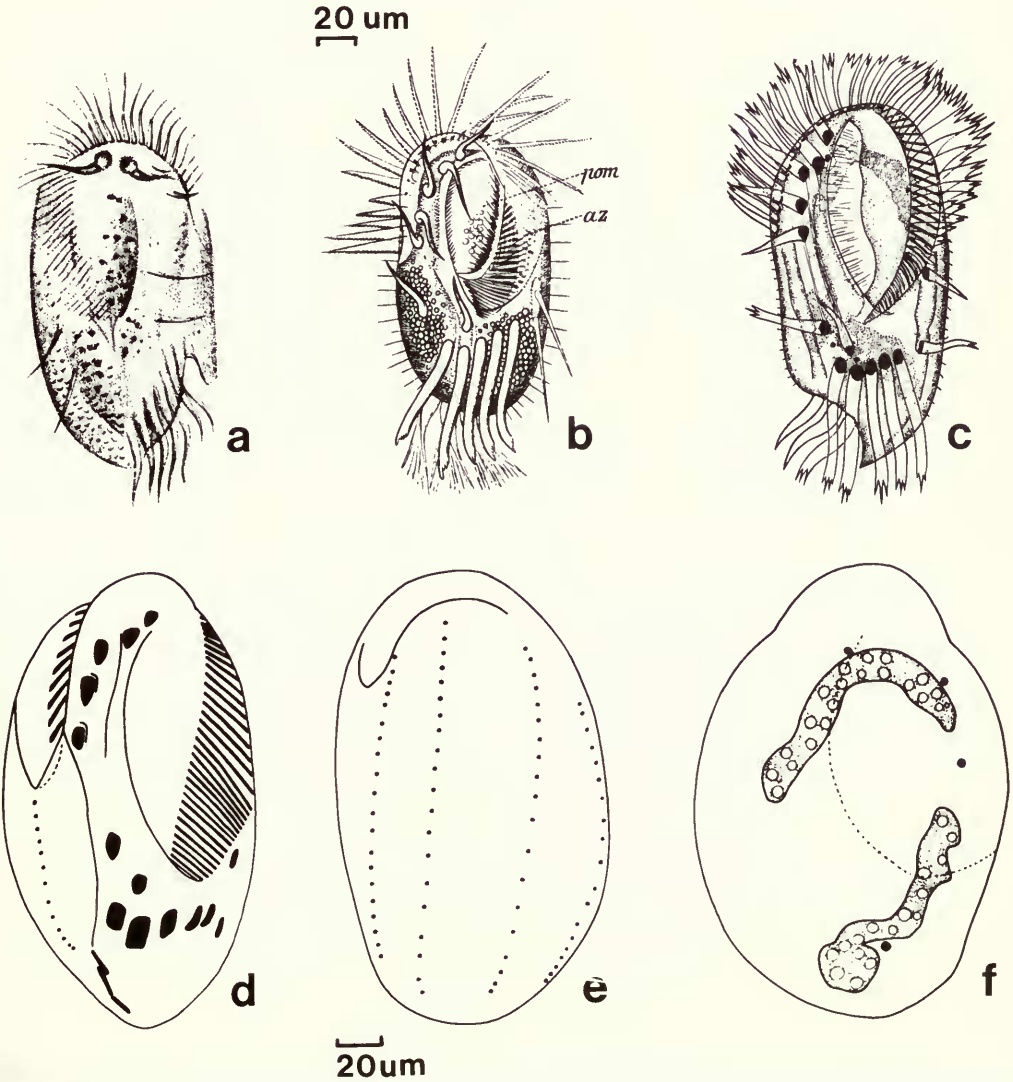

Fig. 11 *Diophrys scutum*: (a) after Dujardin, 1841 (called *Ploesconia scutum*); (b) after Butschli, 1889 (called *Diophrys grandis*); (c) after Dragesco, 1963; (d–f) ventral surface, dorsal surface, and nuclei, after Borror, 1965*a*.

Styloplotes norwegicus Quennerstedt, 1867
Styloplotes grandis Rees, 1881
Styloplotes quennerstedti Rees, 1883
Diophrys grandis Butschli, 1889
Diophrys magnus Raikov & Kovaleva, 1968
Diophrys kasymovi Agamaliev, 1971

DESCRIPTION (Figs 11, 12). This is the largest species (150–200 μm long) of the genus so far described. It may be distinguished from the type species, *D. appendiculata*, by its size and by the AZM which extends to the central body region on the right side. The body shape is ovoid with an indentation in the posterior right. The dorsal surface is smooth and arched. There are 3 large sickle-shaped right caudal cirri, 7–8 frontoventral, 5 transverse and 2 left marginal cirri. The two elongate macronuclei may be curved, nodular or moniliform and are accompanied by up to six micronuclei. The dorsal silver-line system consists of 5–6 dorsolateral kineties interspersed with mesh-like argyromes.

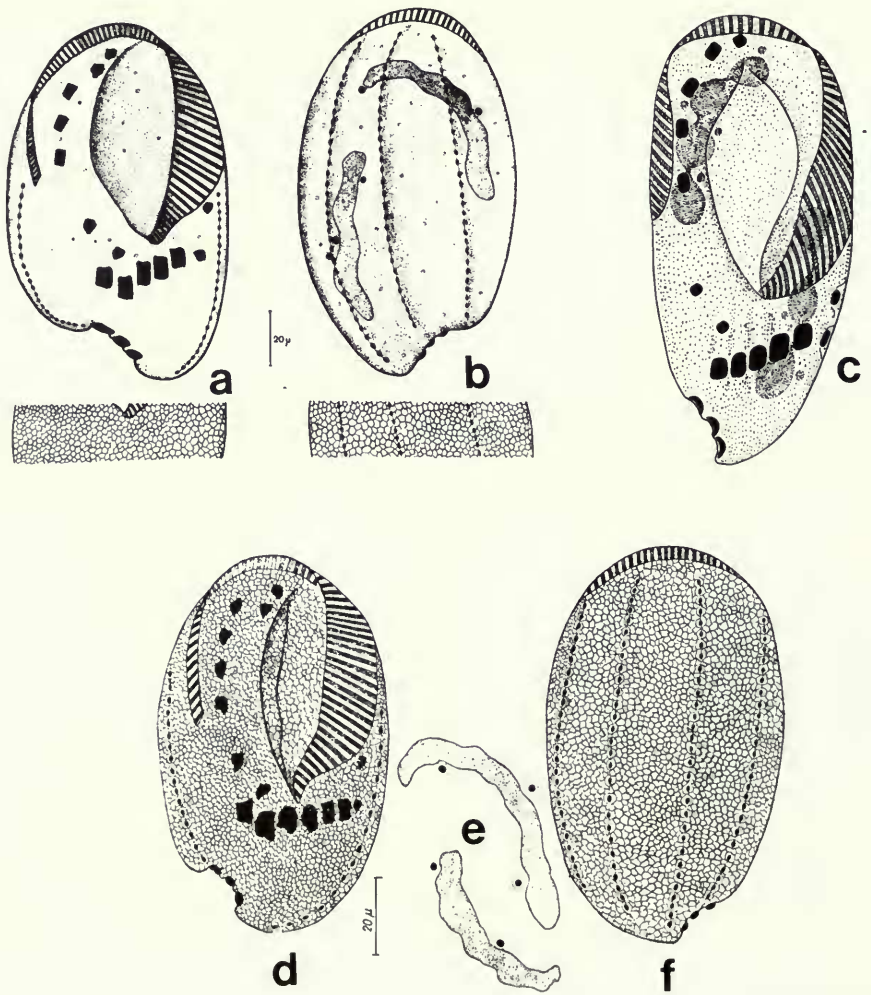

Fig. 12. *Diophrys scutum*: (a, b) ventral and dorsal surfaces with section showing argyromes, after Agamaliev, 1968; (c) after Raikov & Kovaleva, 1968 (called *D. magnus*); (d, f) ventral argyrome, nuclei and dorsal argyrome after Agamaliev, 1971 (called *D. kasymovi*).

NOTES. Claparède & Lachmann (1858) and Stein (1859*a*) believed that the three illustrations of *Ploesconia scutum* by Dujardin (1841) were of two different species. Claparède & Lachmann (1858) thought that one represented a *Euplotes* species whereas Stein (1859*a*) considered it to be *Styloplotes appendiculatus* Stein. The present authors doubt both of these opinions but agree with Kahl (1932) who identified the species as *Diophrys scutum* and considered the AZM originating in the middle of the right border to be an important diagnostic feature. It is mainly by this character that *D. scutum* can be distinguished from *D. appendiculata*. Raikov and Kovaleva (1968) distinguished *D. magnus* from *D. scutum* by the difference in the shapes of their macronuclei which is not a significant feature. The recent addition *D. kasymovi* Agamaliev, 1971 has been included here in spite of it being rather small for this species.

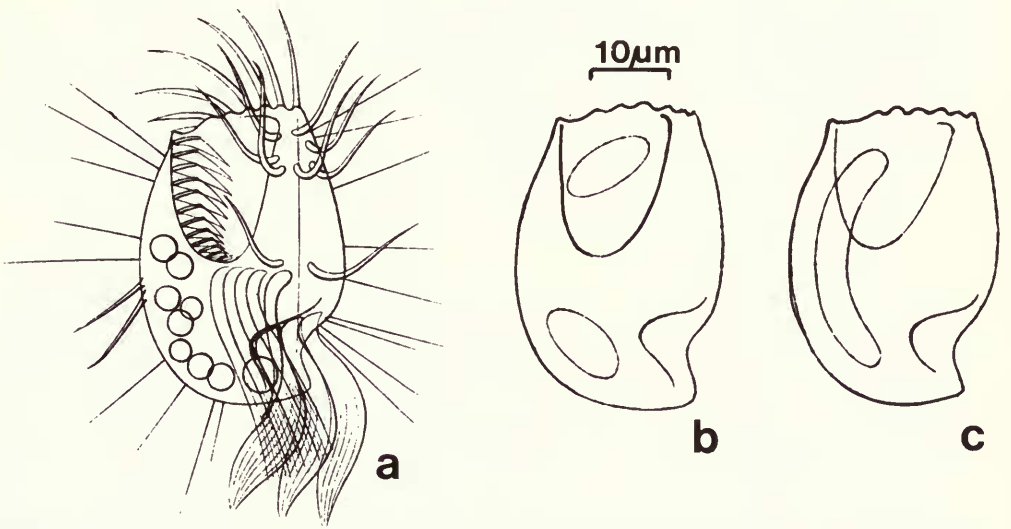

Fig. 13 *Diophrys hystrix*, after Buddenbrock, 1920: (a) ventral surface; (b, c) nuclear features.

Diophrys hystrix Buddenbrock, 1920

DESCRIPTION (Fig. 13). *Diophrys hystrix* is a small (30–40 μm long) species. The body outline is generally oval but it is truncated anteriorly and there is the usual concavity on the posterior right accommodating three large sickle-shaped right caudal cirri. The dorsal surface is strongly arched. The ten frontoventral cirri are arranged in two distinct groups with 7 'frontals' at the anterior on the right of the peristome and 3 'ventrals' near the transverse cirri. One of the 'ventrals' is adjacent and similar in size to the transversals, but it points in the opposite direction and is used in the creeping movements of the animal. There are 4 long transverse cirri and 2 small left marginal cirri located just behind the peristome. There are two ovoid macronuclei.

NOTES. Kahl (1932) gave an almost identical description and illustration of this species as in Buddenbrock's (1920) original. Kattar (1970) identified a small (35–40 μm) species with two ovoid macronuclei as *D. hystrix* but this is a dubious identification since the author gave an inadequate description and the illustration was of a different shape and cirral number to that of Buddenbrock (1920).

Diophrys irmgard Mansfeld, 1923

DESCRIPTION (Fig. 14). This is a medium sized (75–135 μm long) marine species. The body shape is characteristic, being broadly oval in outline but tending to be rectangular. The wide peristome is approximately half the body length and there is a prominent undulating

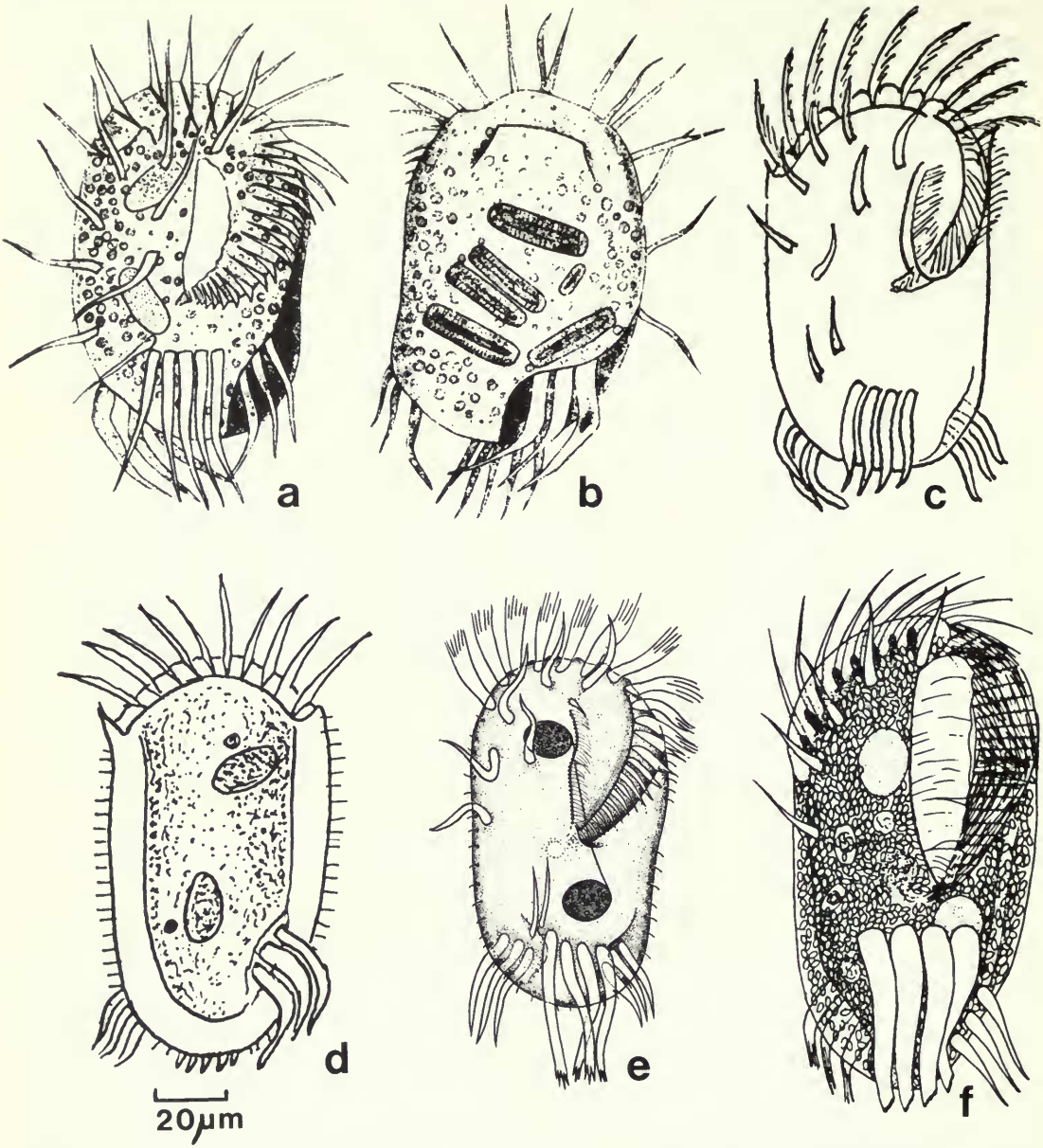

Fig. 14 *Diophrys irmgard*: (a, b) after Mansfeld, 1923; (c, d) after Kahl, 1932; (e) after Dragesco, 1963; (f) after Borror, 1963.

membrane on the right. The AZM bordering its left edge curves around the anterior end but only just extends to the right side of the body. There are 3 right caudal, 9 frontoventral, 4–5 transverse and 3 left marginal cirri. The two ovoid macronuclei are 8 μm in diameter and each is associated with a micronucleus.

NOTES. This species may be distinguished from the type species, *D. appendiculata*, by the presence of 9 instead of 7 frontoventral cirri and because the left marginal cirri are in the 'caudal' position. The shape of its body is consistently observed to be widely oval, rectangular and lacks the posterior lateral concavity on the right which is usually charac-

teristic of the genus. Additionally, the right caudal cirri are attached dorsally like those of *Uronychia*. Borror (1963) described an organism which he called *D. irmgard* but as it had only 5 frontoventral cirri perhaps future studies will show this to be a separate species.

Diophrys salina Ruinen, 1938

DESCRIPTION (Fig. 15). This is a small (30–40 μm long) species. The outline shape of the body is characteristically oval without any obvious lateral concavities but there is a posterior indentation where the 3 large caudal cirri arise. The dorsal surface is strongly convex, but the ventral surface is flattened. The peristome region extends to the centre of the body, with an AZM on the left and a well developed undulating membrane on the right. The frontoventral cirri are arranged in two groups with 4 right anterior 'frontals' and 4 'ventrals' situated immediately behind, and to the right of, the peristome. There are no left marginal cirri. Five transverse cirri lie between the caudal and 'ventral' cirri. The original description did not include any details concerning the nuclear apparatus. Feeds on diatoms, algae and bacteria.

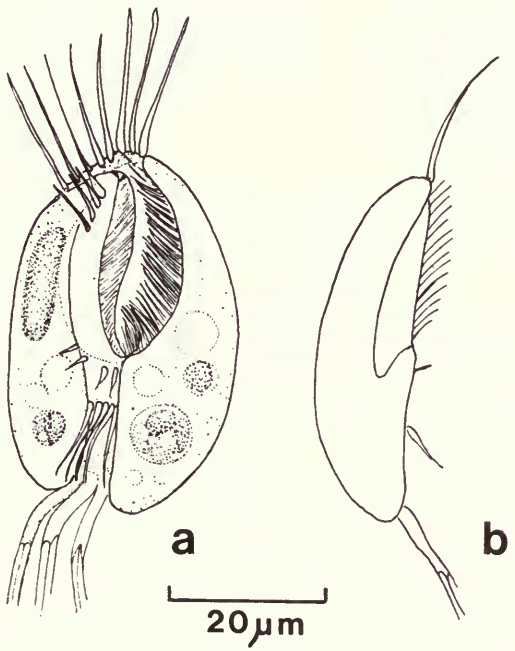

Fig. 15 *Diophrys salina*: (a, b) ventral surface and lateral view, after Ruinen, 1938.

Diophrys kahli Dragesco, 1963

DESCRIPTION (Fig. 16). This species is about 80 μm long, the body is elongate with a short posterior narrowed tail region. The peristome is small, bordered on the right by a well developed undulating membrane and on the left by a small AZM. The frontoventral cirri consist of a group of 7 long 'frontals' and 2 small 'ventrals'. The 5 transverse cirri are long, the 2 left marginal cirri are in the 'caudal' position and there is only one right caudal cirrus. The two oval macronuclei are connected by a nuclear membrane and there are 4–6 micronuclei. A few cilia have been observed along the left border of the animal.

NOTES. Dragesco (1963) identified an organism that he considered to be identical to one incompletely studied by Kahl (1932) which he called *D. kahli*. Untypically, the body of this species is rather elongate and its left marginal cirri emerge caudally instead of immediately posterior to the peristome. Hartwig (1974) grouped this species with *D. irmgard* and *D.*

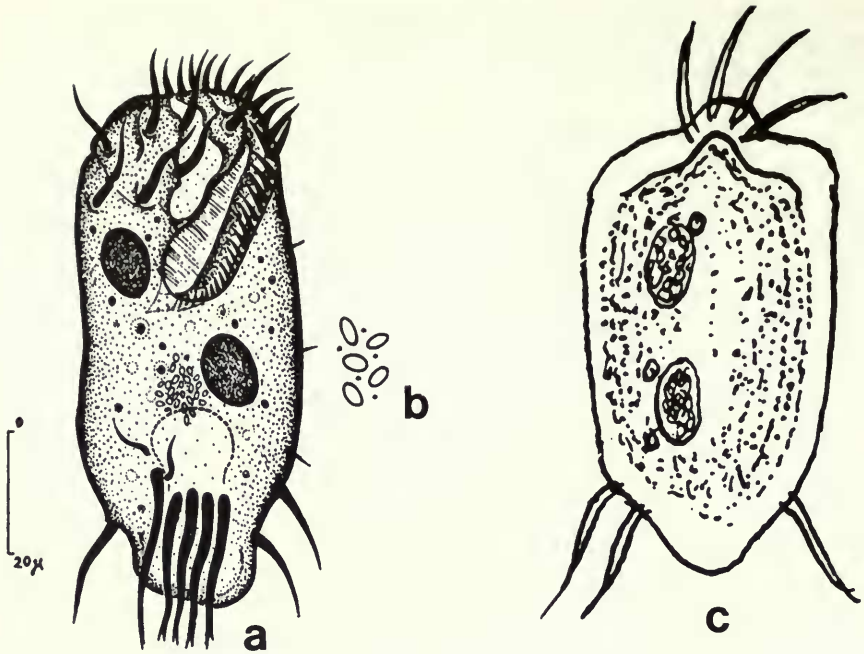

Fig. 16 *Diophrys kahli*: (a, b) ventral surface and dorsal plaques, after Dragesco, 1963; (c) dorsal surface, after Kahl, 1932 (called an 'incompletely studied *Diophrys* species').

multinucleata because of this latter feature. In contrast to other species in the genus, *D. kahli* has only one right caudal cirrus, its peristome is rather small and the AZM is underdeveloped. Dragesco (1963) described the presence of small oval plaques on the dorsal surface (Fig. 14b) which he suspected to be 'protrichocysts'.

Diophrys oligothrix Borror, 1965

DESCRIPTION (Fig. 17). *Diophrys oligothrix* is a medium sized (79–106 μm long), ovoid species. The concavity at the posterior right edge, so typical of the genus, is here inconspicuous and the dorsal surface smooth. The AZM bordering the left edge of the large peristome continues dorsally along the anterior region to the right side of the body. The ciliature and nuclear features are also typical of the genus, there are 7 frontoventral, 5 transverse, 2 left marginal and 3 right caudal cirri. The two irregular, elongate macronuclei are usually accompanied by four micronuclei. The silver-line system consists of 3 dorsal kineties, one lateral kinety on the right and a fine mesh-like argyrome. The dorsal kineties bear, from left to right, 13–20, 16–24, 12–18 cilia and the ventral kinety 9–13 cilia.

NOTE. This species is distinguished from *D. scutum* on the basis of its different number of kineties.

Diophrys peloetes Borror, 1965

DESCRIPTION (Fig. 18). *D. peloetes* is a medium sized (95–135 μm long) species typical of the genus. It has a wide peristome which is about two-thirds of the body length, bordered by a well developed AZM on the left and an undulating membrane on the right. The AZM travels along the anterior dorsal edge onto the right side of the body where it extends about 3/10 of the body length. There are 3 prominent right caudal cirri, 5 long transverse, 7 frontoventral and 2 left marginal cirri. The two macronuclei are elongate. There are 8 dorsolateral

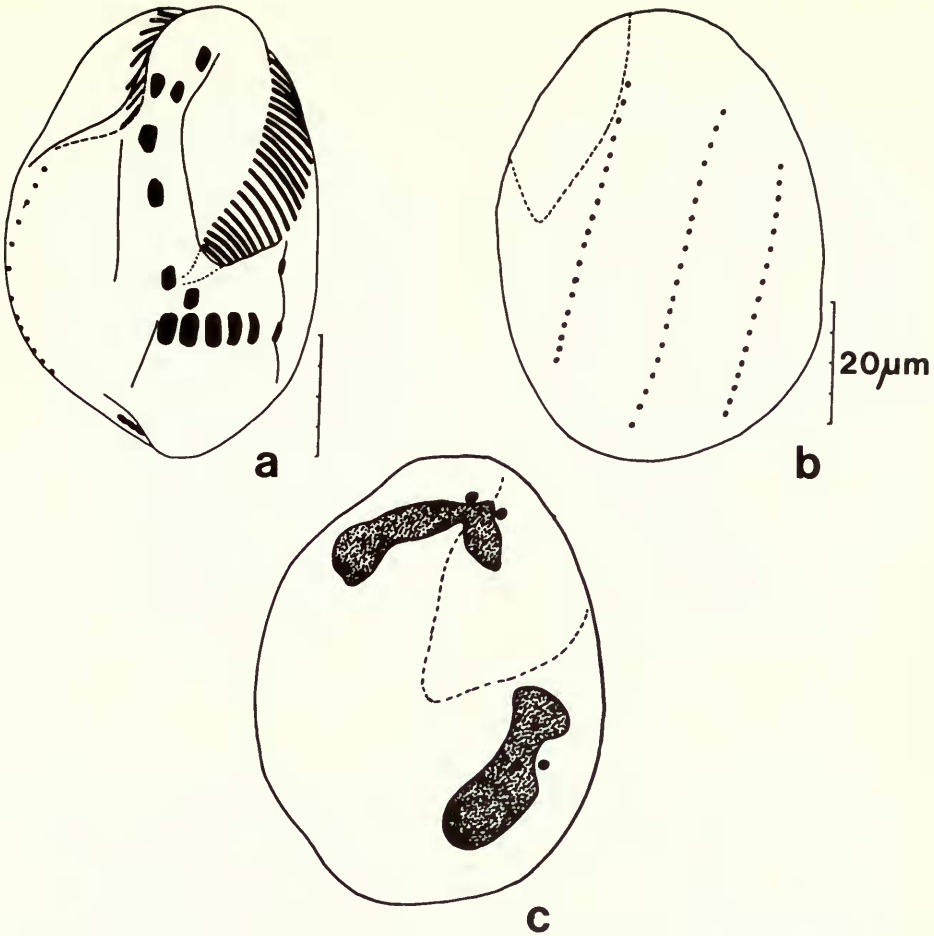

Fig. 17 *Diophrys oligothrix*, after Borror, 1965*b*: (a) ventral surface; (b) dorsal surface; (c) frontal section showing nuclei.

kineties, each bearing 6–17 cilia. The number of kineties distinguishes this species from *D. scutum* which has only five.

NOTES. Borror (1965*a*) established *D. peloetes* after a morphometric comparison with *D. scutum*. He stated that the new species was 'extremely similar to *D. scutum* except for having eight dorsal rows of cilia instead of five, having fewer cilia per row, and having a significantly shorter AZM'. He also pointed out that he had identified it incorrectly as *D. scutum* in an earlier study (Borror, 1963).

Diophrys quadricaudatus Agamaliev, 1967

DESCRIPTION (Fig. 19). This is a medium sized (100–110 μm long) species, characterised by the presence of 4 right caudal cirri arising from a particularly prominent concavity on the posterior right of an otherwise oval body. The wide peristome is about 48 μm long and on its right there is a conspicuous undulating membrane. The AZM is composed of 50–60 membranelles which extend forward over to the right side of the body. There are 7 frontoventral, 5 transverse, and 3 left marginal cirri. The dorsal silver-line system consists of 5 or 6 dorsolateral kineties and a finely-meshed dorsal argyrome. There are two anterior and one posterior macronuclei.

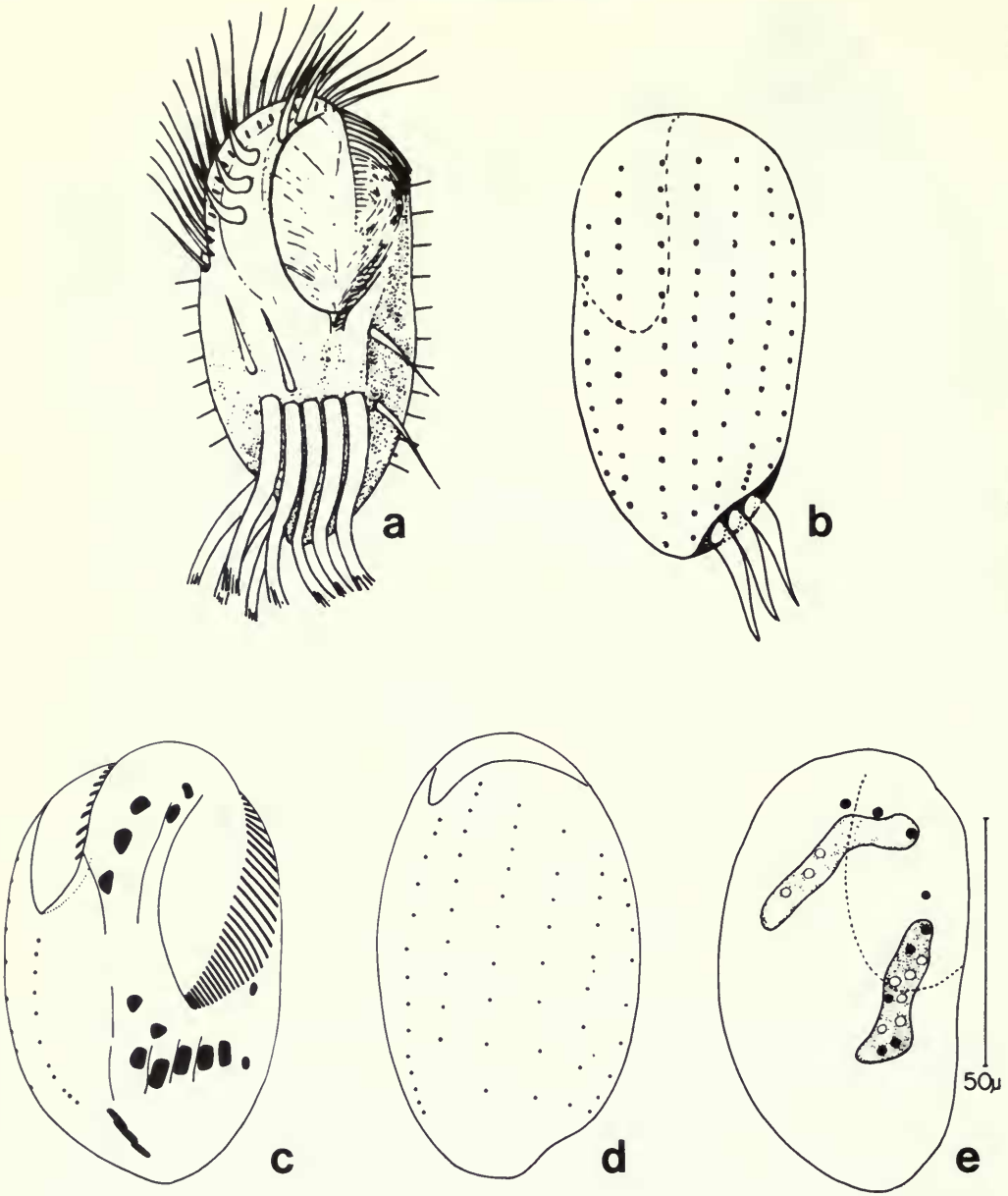

Fig. 18 *Diophrys peloetes*: (a, b) ventral and dorsal surfaces, after Borror, 1963 (called *D. scutum*); (c–e) ventral and dorsal silver-line systems, and nuclei, after Borror, 1965*a*.

NOTES. Agamaliev (1967) considered the presence of four right caudal cirri and three macronuclei to be the diagnostic features of this species. The uneven number of macronuclei is rather strange and could perhaps represent an interdivisional state.

Diophrys scutoides Agamaliev, 1967

DESCRIPTION (Fig. 20). *D. scutoides* is 110–120 μm long. The body is oval with a prominent concavity on the posterior right edge. The AZM of 75–80 membranelles borders the left edge of a wide peristome and continues along the anterior edge to extend a third of the body length

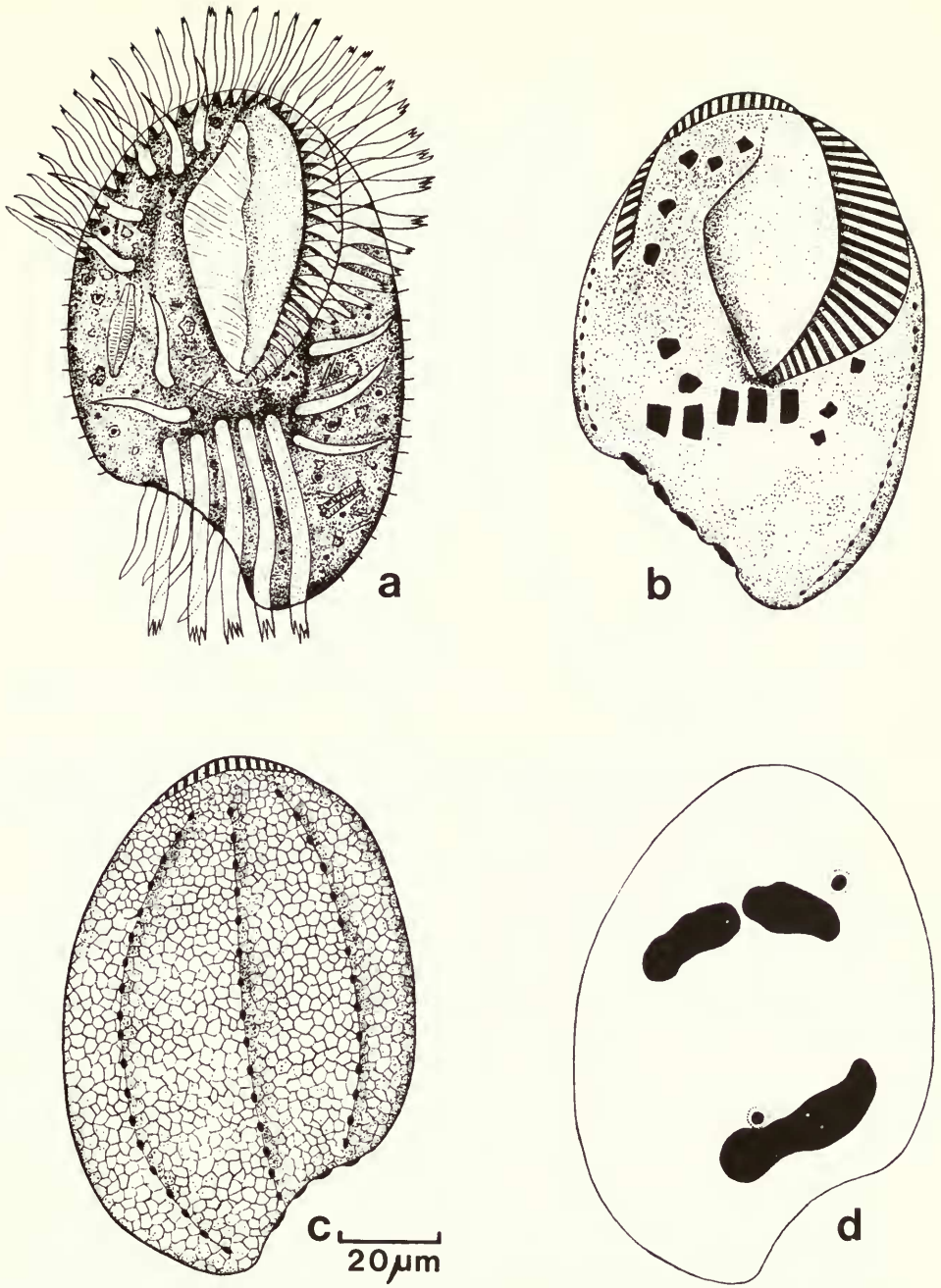

Fig. 19 *Diophrys quadricaudatus*, after Agamaliev, 1967: (a) ventral surface of living cell (b–d) stained ventral surface, dorsal surface and nuclei.

down the right side. There are 3 right caudal, 5 transverse and 2 left marginal cirri but only 5 frontoventral cirri. The two elongate macronuclei are nodular and are accompanied by three micronuclei. The silver-line system consists of 5 dorsolateral kineties with mesh-like dorsal and ventral argyromes.

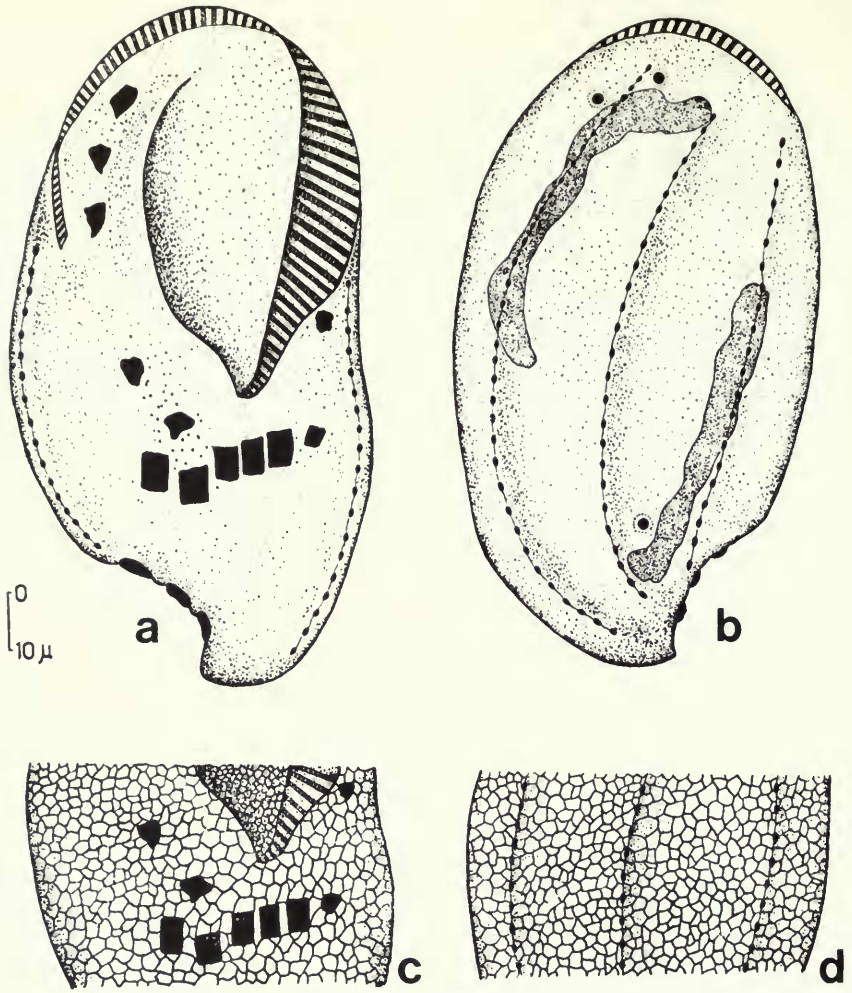

Fig. 20 *Diophrys scutoides*, after Agamaliev, 1967: (a) ventral surface; (b) dorsal surface; (c, d) ventral and dorsal argyromes.

NOTES. Agamaliev (1967) described this species from the Caspian Sea. Apart from being slightly smaller in size, it differs from *D. scutum* in having five instead of seven frontoventral cirri.

Diophrys tetramacronucleata Kattar, 1970

DESCRIPTION (Fig. 21). This is a small (55–65 μm long) species. The body is oval except for the concavity at the posterior right edge. The AZM consists of about 36 membranelles which extend about halfway down the body on the left but hardly at all on the right. There are 7 frontoventral, 5 transverse, 2 left marginal and 3 right caudal cirri. There are 5 dorsolateral kineties and 4 ovoid macronuclei.

NOTES. The original description of this species was brief and only the presence of four macronuclei distinguished it from the type species. Although it is suspected that Kattar (1970) described an interdivisional specimen, it is provisionally included here as a nominal species. Kattar (1970) stated that protargol impregnation showed the presence of three median and two dorsolateral kineties he provided no diagram of these structures. The

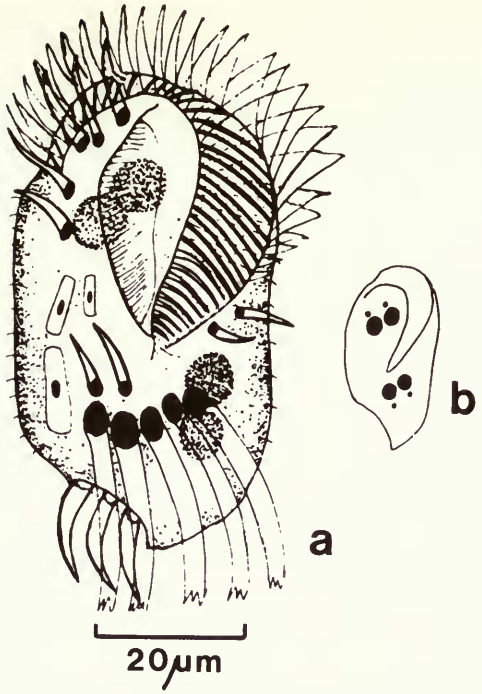

Fig. 21 *Diophrys tetramacronucleata*, after Kattar, 1970: (a) ventral surface; (b) nuclei.

redescription and photographs of this species by Hartwig (1974) are also incomplete although the presence of four macronuclei was clearly demonstrated.

Diophrys multinucleata Hartwig, 1973

DESCRIPTION (Fig. 22). *D. multinucleata* is a medium sized (76–118 μm long) highly thigmotactic species. The body is oval to rectangular in outline with the dorsal surface being arched and the ventral surface flattened. There is a small but distinct projection on the anterior right corner of the body. The peristome is about two-thirds of the body length. The AZM consists of about 30 membranelles lying along the left of the peristome and a few larger membranelles along the anterior edge of the body. The frontoventral cirri are arranged in two distinct groups: the 5–6 large 'frontals' are in the anterior and the two very small 'ventrals' lie close to the transverse cirri. There are 4 long transverse, 3 right caudal and 3 left marginal/caudal cirri. There are at least 20 macronuclei present.

NOTES. This species is characterised by the presence of over twenty macronuclei which is unique in the genus, otherwise it is similar to *D. irmgard* in cirral arrangement, particularly in the caudal positioning of the left marginal cirri which Hartwig (1973, 1974) considered to be a feature of diagnostic importance.

Genus ***URONYCHIA*** Stein, 1859

Introduction

Stein (1859*a*, 1859*b*) established and described the genus *Uronychia* and transferred *Trichoda transfuga* Muller, 1786 to the genus as the type species. Between 1901 and 1928, five new species were described and Kahl (1932) included a key to them in his classical compendium. Since then only one addition, *Uronychia bivalvorum* Fenchel, 1965, has been

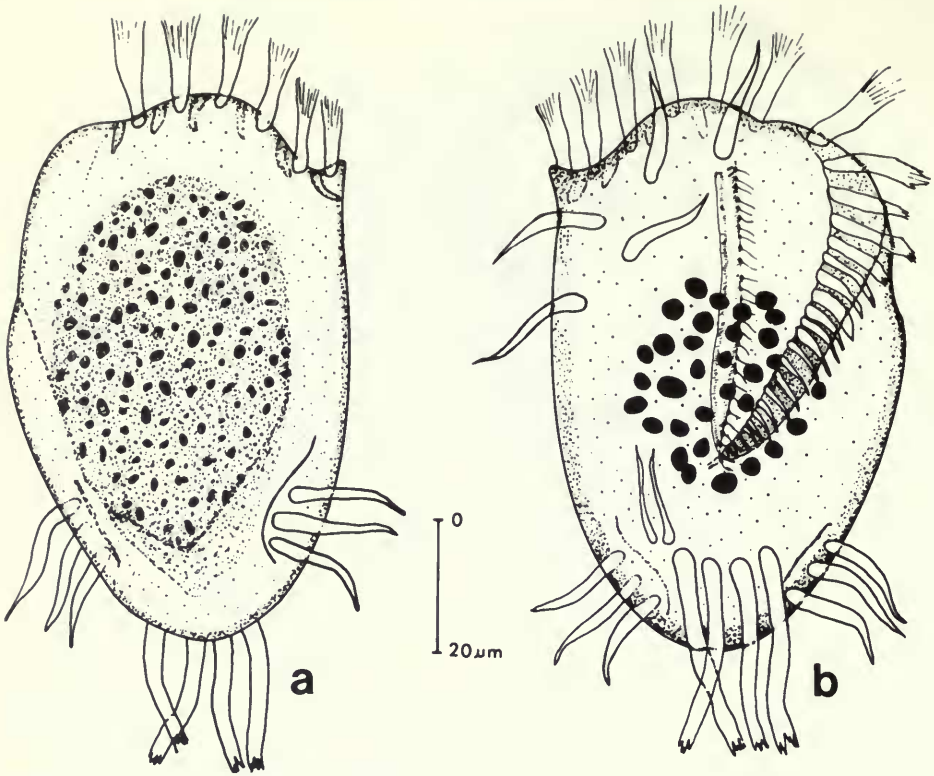

Fig. 22 *Diophrys multinucleata,* after Hartwig, 1973: (a) dorsal surface; (b) ventral surface showing nuclei.

made which he found in the mantle cavity of certain lamellibranch molluscs. *Uronychia* is characterised by its enormous peristome region occupying half of the ventral surface with conspicuous peristomial membranes, the three posterior groups of large cirri, the apparent absence of frontoventral cirri and by its rapid backward motion (Bullington, 1940). However, there are few features which clearly distinguish the described species from one another. Many of the features used in the past are variable so that here only four nominal species are recognised.

(*a*) *Shape.* The typical *Uronychia* body is oval. Dorsal ribs, ridges or striations are often mentioned in descriptions but there are few data on the variability of these structures. Ventrally, there are two large posterior cavities which accommodate the transverse and left marginal cirri. In general, the right caudal cirri of *Uronychia* are attached more dorsally than those in *Diophrys*, so the oval body outline is without the dorsolateral concavity at the posterior right which is characteristic of the latter genus. However, Buddenbrock (1920) described *U. heinrothi* with an 'Ausschnitt' (notch) on the posterior right edge which can make the posterior border S-shaped. Similarly, Taylor (1928) described an 'uncinus' on *U. uncinata* which he stated apparently owes its origin in part to an attenuation of the remnant which holds proter to opisthe during the final stages of division.

It seems likely that the 'Ausschnitt' and 'uncinus' are the same structure and as Buddenbrock (1920) noted that it was variable in extent and absent from some individuals then it cannot be used as a reliable diagnostic character. Indeed if it is formed during division then it could only be present in the proter of a dividing cell.

(*b*) *Size.* The distinctive sizes of *U. magna* and *U. setigera* are here considered to be

diagnostically significant. The former at 450 μm long is the largest species so far described in the family Euplotidae, and the latter at 40–50 μm long is the smallest *Uronychia* species. The sizes of the remaining species fall within the range of 70–250 μm long. The size of the type species *U. transfuga* has been noted to vary between 50–150 μm long (Kahl, 1932) but Bullington (1940) separated *U. heinrothi* from *U. transfuga* by the larger size (129–264 μm long) of the species he observed. However, Buddenbrock (1920) described *U. heinrothi* as having the range 70–250 μm in length. It is apparent that the size variation of these two species is great and their ranges overlap. Since there are no other significant distinguishing features, these two species are here regarded as being synonymous.

(*c*) *Adoral Zone of Membranelles.* The ventral surface of *Uronychia* is dominated by an enormous peristome with conspicuous membranelles and membranes. Unlike the rest of the Euplotidae, the AZM of *Uronychia* consists of large membranelles along the anterior of the body and 4–5 smaller paroral membranelles at the posterior left of the peristome and there are undulating membranes along both sides of the peristome. Fenchel (1965) was of the opinion that it was the fusion of the adoral membranelles which forms the membrane along the left peristomial border. These peristomial membranes and membranelles may be observed to be closed over the peristome region or spread out and wing-like. The paroral membranes are often found in a pocket-like invagination of the peristomial wall.

Buddenbrock (1920) described the presence of two large peristomial membranes in *U. heinrothi* but these appear to be split into five parts in one of his diagrams. Bullington (1940) observed four peristomial membranes on his specimens of *U. heinrothi* plus another large membrane close to the posterior right edge of the body. This marginal membrane has been described only on this occasion so it has not been used here as a diagnostic character. Although the peristomial membranes of *U. heinrothi* appear to be larger and more numerous than has been observed in *U. transfuga*, it is not considered to be a reliable character. On the other hand, Calkins (1902) described 'flagella-like' cirri in the peristome of *U. setigera* which have subsequently been noted by other authors (Buddenbrock, 1920; Young, 1922; Kahl, 1932; Kattar, 1970). This feature is apparently distinctive and consistent and is therefore useful in the identification of *U. setigera.*

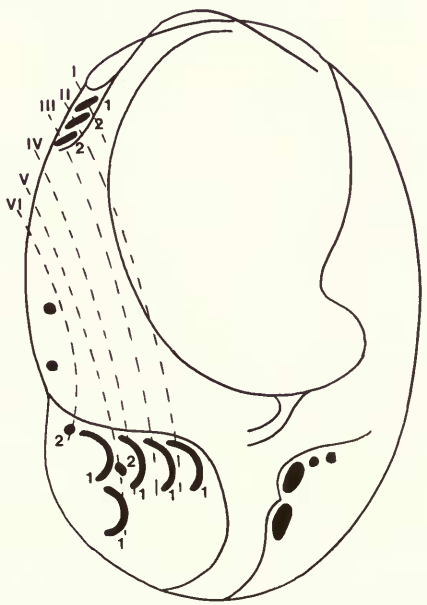

Fig. 23 Arrangement and numbering of cirral streaks in *Uronychia transfuga*, after Wallengren, 1901.

(*d*) *Cirri.* One of the most distinctive generic features of *Uronychia* is the apparent absence of frontoventral cirri. Wallengren (1901) studied cirral morphogenesis in *U. transfuga* and was first to number the cirral streaks (Fig. 23). He found that there was a small residuum of cirral elements I/1, II/2 and III/2 grouped closely together at the anterior right near the adoral membranelles which he described as membranous cirri. Young (1922) noted these in three *Uronychia* species and described them as cirri-like membranelles, but it was Buddenbrock (1920) who illustrated three similar small cirrus-like structures at the anterior left as well as on the right. Wallengren (1901) showed that the cirri V/2 and VI/2 which form the 'ventrals' in *Euplotes* and *Diophrys* lie among the transversals in *U. transfuga* and they appear like 'satellites' in this group of cirri. These cirri have not yet been observed by other authors but Buddenbrock (1920), Young (1922) and Taylor (1928) described the presence of one slender cirrus at the right of the transversals in *U. setigera*, *U. heinrothi* and *U. uncinata.*

All species of *Uronychia* have 4 or 5 transverse cirri. Young (1922) considered the possession of four transversals in *U. binucleata* to be a specific character even though he recorded that the number of transversals in *U. transfuga* varied between 4 and 5. To the left of the ventral cavity from which the transversals emerge, there is another cavity which accommodates the two enormous left marginal cirri with a variable number of small cirri or cilia. The right caudal cirri emerge dorsally on the posterior right and are invariably sickle-shaped. All of the described species have three right caudals except *U. magna* which was shown as having two by Pierantoni (1909), although he also observed only two right caudals in *U. transfuga* which others have shown to possess three. Bullington (1940) discussed the attachment and movement of the right caudal cirri in *Uronychia* (Fig. 24).

In addition to these three groups of large cirri, two small right marginal cirri have been observed in most *Uronychia* species. Fenchel (1965) distinguished *U. bivalvorum* from *U. transfuga* partly by the absence of these two small cirri but it should be noted that both *U. transfuga* and *U. setigera* have also been described without right marginals.

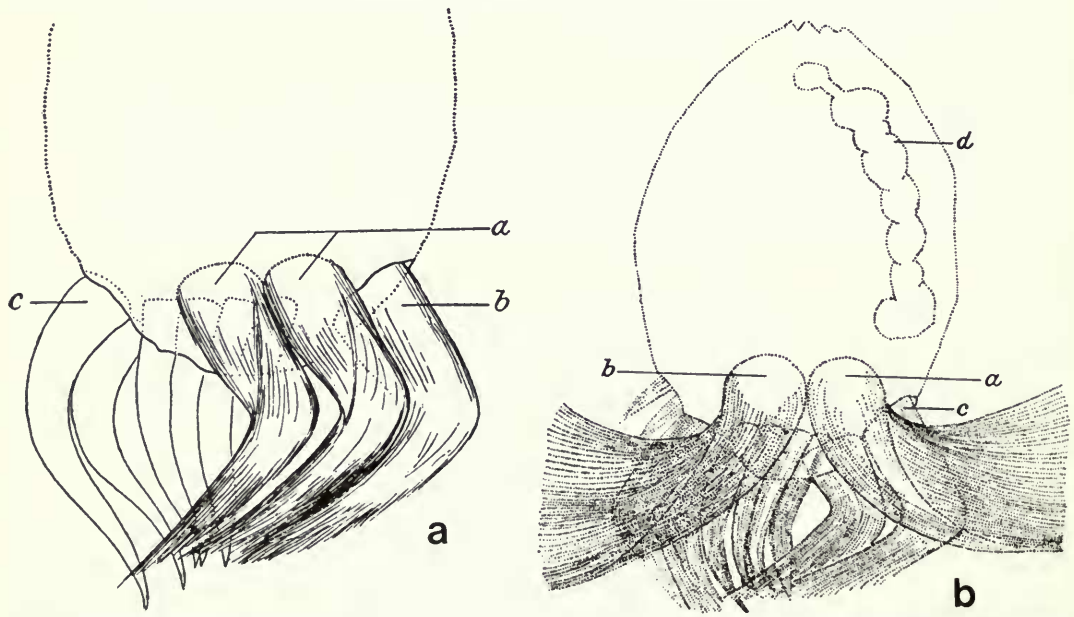

Fig. 24 Arrangement of the right caudal cirri of *Uronychia transfuga*, after Bullington, 1940 (called *U. heinrothi*): (a) showing two large cirri attached in the mid-dorsal region of the posterior body end with a cirrus on the right; (b) showing two defimbriated cirri attached to either side of the mid-line and one cirrus attached in a pocket near the right edge and slightly below the other two cirri.

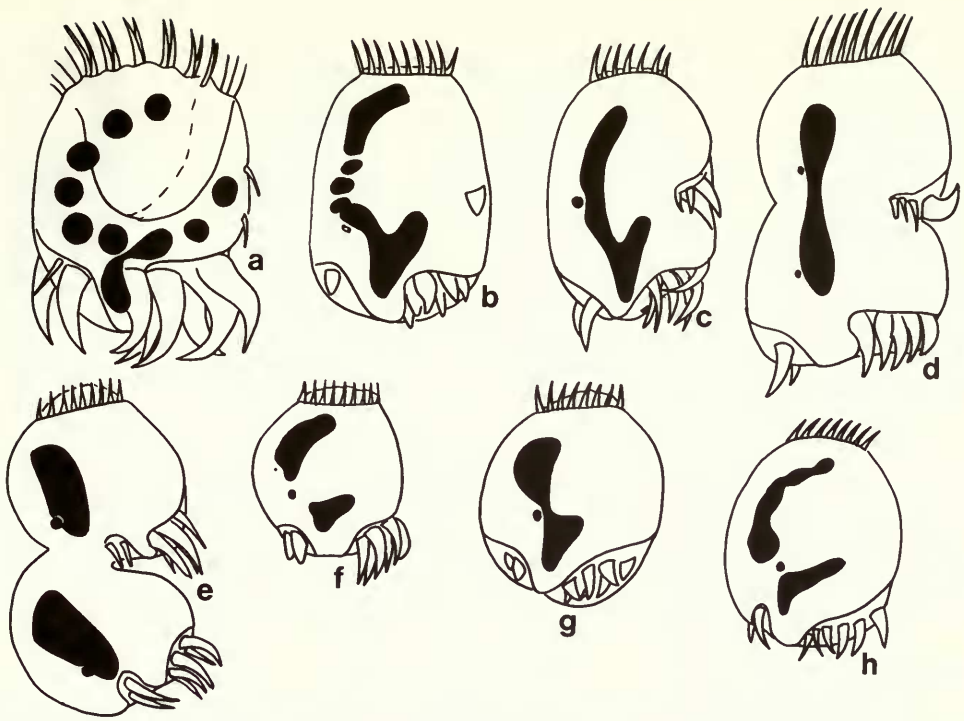

Fig. 25 Stages in cell division of *Uronychia transfuga*, after Calkins, 1911: (a) resting stage; (b) condensation of the macronucleus; (c, d) later stages in division; (e) just before cell separation; (f–h) daughter cells immediately, 15 minutes and 1 hour after separation.

Kahl (1932) noted the presence of a long slender right caudal cirrus in *U. binucleata* which he considered to be of diagnostic value, similarly Young (1922) described such a cirrus in *U. setigera* although no others have reported its presence. It is evident that cirral numbers and arrangements in this genus are highly variable and therefore of little diagnostic importance.

(*e*) *Nuclear features*. Kahl (1932) relied heavily on the nuclear features of *Uronychia* in his key to the species. For example, he stated that *U. transfuga* had, without exception, two sausage-shaped macronuclei with a micronucleus and that *U. magna* and *U. heinrothi* had their nuclei split into many fragments. However, *U. transfuga* had already been seen with its macronucleus in many fragments. Calkins (1911) described the nuclear reorganisation of *U. transfuga* and showed that the macronucleus just after cell division was in two parts but that it was a fragmented C-shape when at the resting stage (Fig. 25). The macronucleus of *U. transfuga* has been described as having a fragmented C-shape, like a string of beads or partially fused, and in two parts (Fig. 26) (Buddenbrock, 1920; Bullington, 1940). Borror (1972) has also noted that the macronuclear shape and number were variable and for this reason considered *U. heinrothi* to be synonymous with the type species.

Calkins (1902) described *U. setigera* with a single ovoid macronucleus but Young (1922) observed two irregular macronuclei in his specimens of the same species. Fenchel (1965) distinguished *U. bivalvorum* from the type species partly on the basis of its nucleus which he described as 'an irregular structure divided into two or more parts of unequal size': this would lie within the range of variability already noted above for *U. transfuga*. Kattar (1970) distinguished between *U. transfuga* and *U. setigera* by their possession of 9–15 and 2 nodular macronuclei respectively, although he also concluded that the six species recognised by Kahl (1932) including *U. setigera* could be varieties of *U. transfuga*. Although the number and shape of the macronuclei in *Uronychia* appear to be highly variable this is not the case with

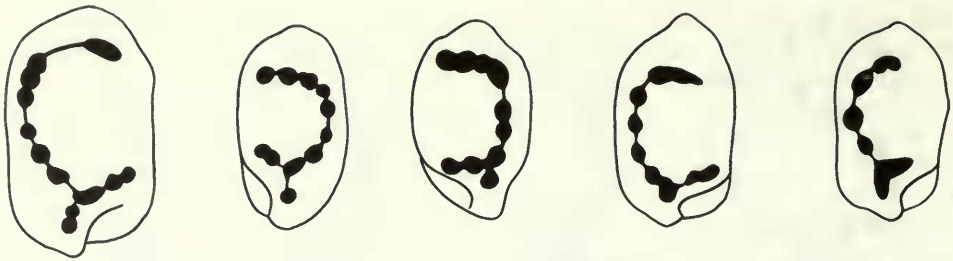

Fig. 26 Nuclear variation in *Uronychia transfuga*, after Buddenbrock, 1920 (called *U. heinrothi*).

the micronucleus. Most species possess a single micronucleus but *U. binucleata* is characterised by the presence of two micronuclei. Only one other species, *U. magna*, has been recorded with two micronuclei.

(*f*) *Dorsal silver-line system.* Kattar (1970) noted the presence of four kineties on the dorsal surface of *U. transfuga* and five on *U. setigera*, while Reiff (1968) illustrated five dorsolateral kineties on the former species. The kineties which have only recently been described appear to correspond in number and position with the dorsal ridges and striations that are sometimes described by earlier authors. However, far more data are required before the diagnostic importance of the silver-line systems of *Uronychia* can be assessed.

Diagnosis of *Uronychia*

Marine hypotrichs of variable size, mostly within the range 50–250 μm long, but up to 450 μm long. Body oval and smooth in outline, dorsal surface smooth or with ridges. Peristome large with conspicuous membranes. The AZM is limited to the anterior border and the paroral region. There are 4–5 transverse and 2 left marginal cirri which emerge from prominent ventral cavities. The 3 large right caudal cirri are attached to the dorsal surface and there are sometimes 2 right marginal cirri present. The frontoventral cirri are reduced to a field of 3 near the origin of the AZM. The macronuclei are variable in number and shape and there are 1 or 2 micronuclei. Characteristically moves backwards rapidly.

Key to the species of *Uronychia*

1	50–250 μm long	2
	Smaller than 50 μm long or larger than 250 μm long	4
2	With a single micronucleus.	3
	With two micronuclei	5
3	Peristomial cirri present	***U. setigera***
	Peristomial cirri absent	***U. transfuga***
4	40–50 μm long	***U. setigera***
	About 450 μm long	***U. magna***
5	About 450 μm long, macronucleus moniliform and C-shaped	***U. magna***
	60–80 μm long, macronucleus in 3–5 pieces	***U. binucleata***

Species descriptions

Uronychia transfuga (Muller, 1786) Stein, 1859

Trichoda transfuga Muller, 1786
Ploesconia scutum Dujardin, 1841 (in part)
Campylopus paradoxus Claparède & Lachmann, 1858
Uronychia heinrothi Buddenbrock, 1920
Uronychia uncinata Taylor, 1928
Uronychia bivalvorum Fenchel, 1965

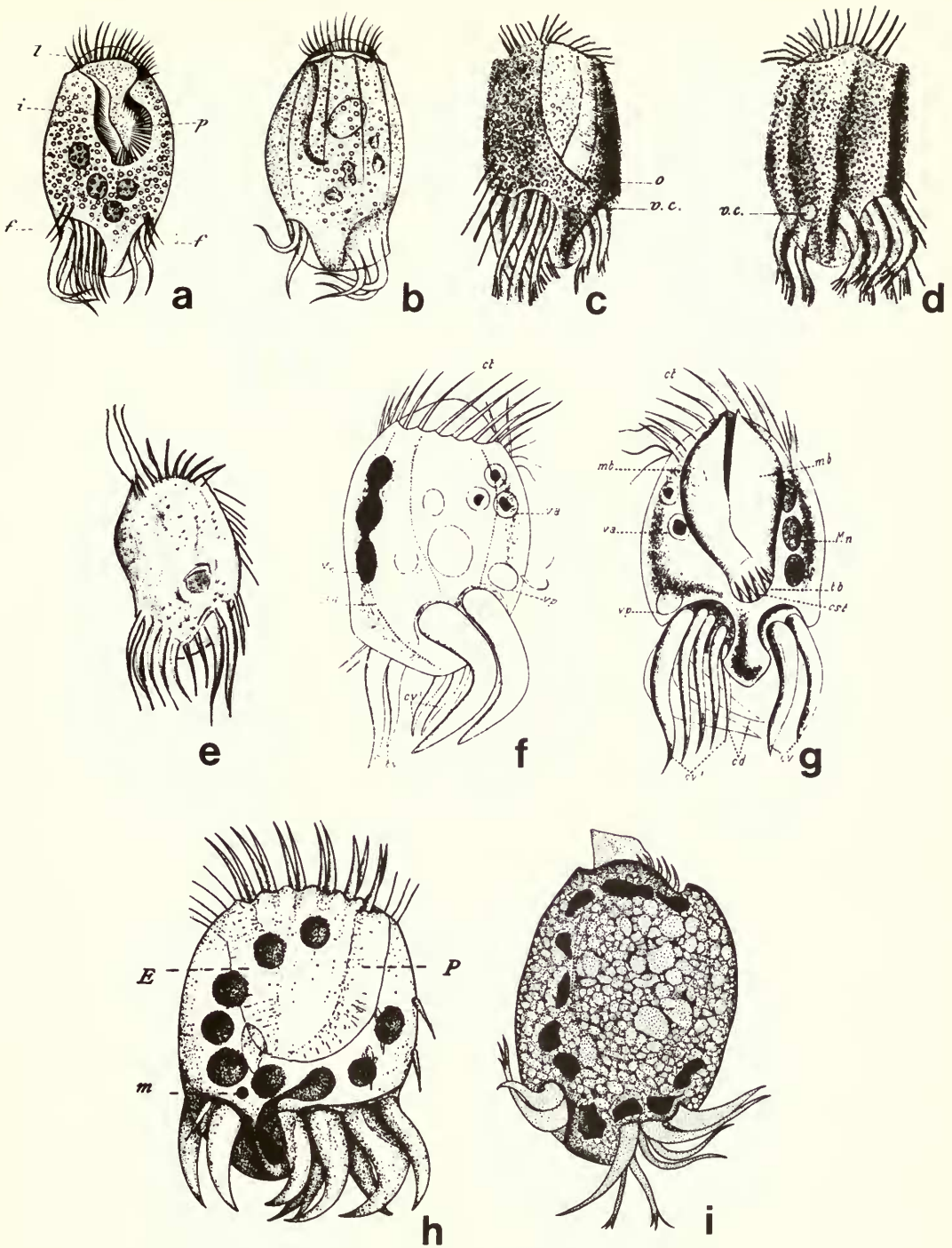

Fig. 27 *Uronychia transfuga*: (a, b) ventral and dorsal surfaces, after Stein, 1859*a*; (c, d) ventral and dorsal surfaces, after Claparède & Lachmann, 1858 (called *Campylopus paradoxus*); (e) dorsal surface, after Dujardin, 1841 (called *Ploesconia scutum*); (f, g) ventral and dorsal surfaces showing nuclei, after Pierantoni, 1909; (h) ventral surface and nuclei, after Calkins, 1911; (i) dorsal surfaces and nuclei, after Young, 1922.

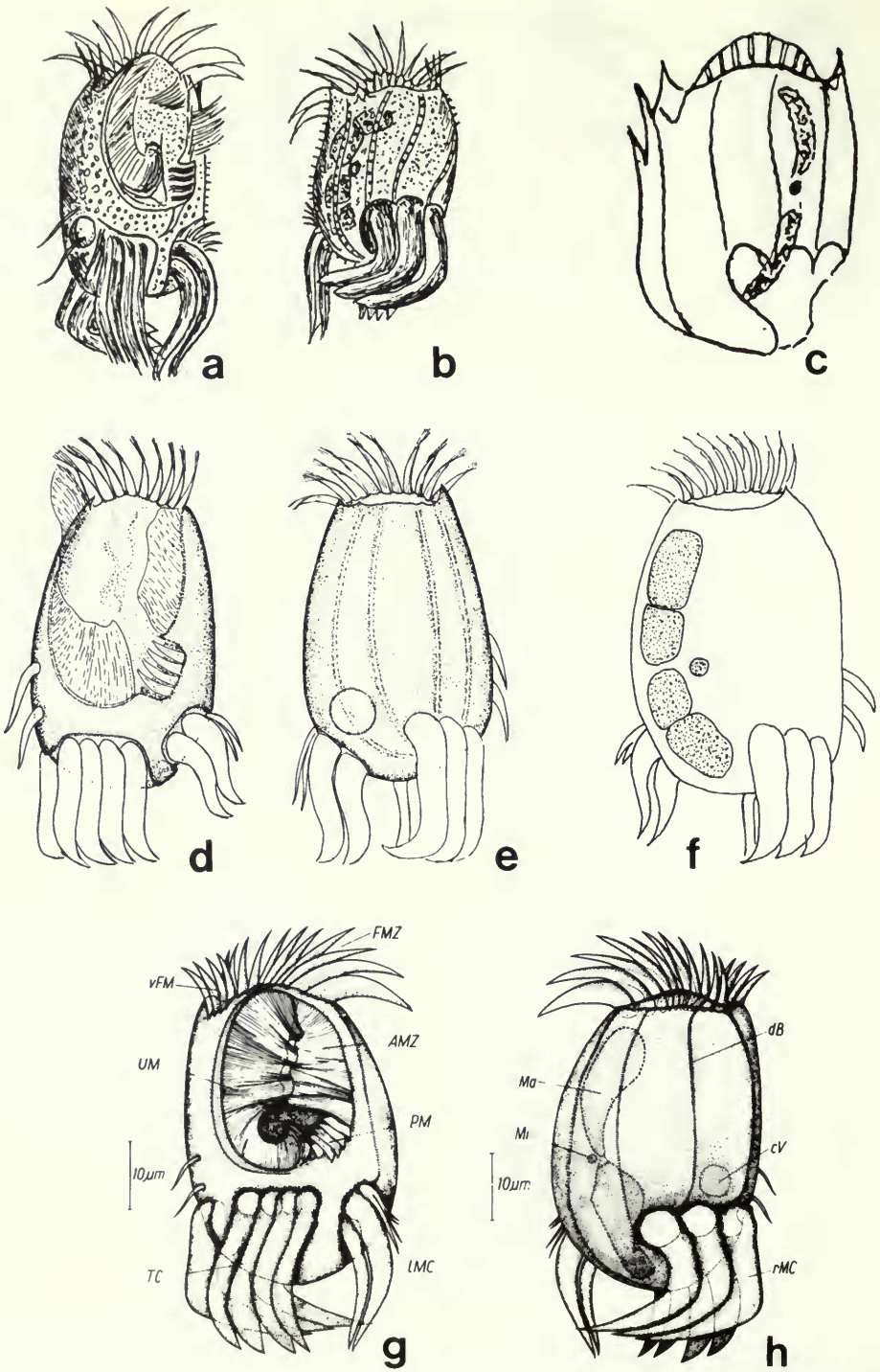

Fig. 28 *Uronychia transfuga*: (a–c) ventral and dorsal surfaces showing nuclei, after Kahl, 1932 (c called *U. uncinata*); (d–f) ventral and dorsal surfaces and nuclei, after Fenchel, 1965 (called *U. bivalvorum*); (g, h) ventral surface and dorsal surfaces showing nuclei, after Reiff, 1968.

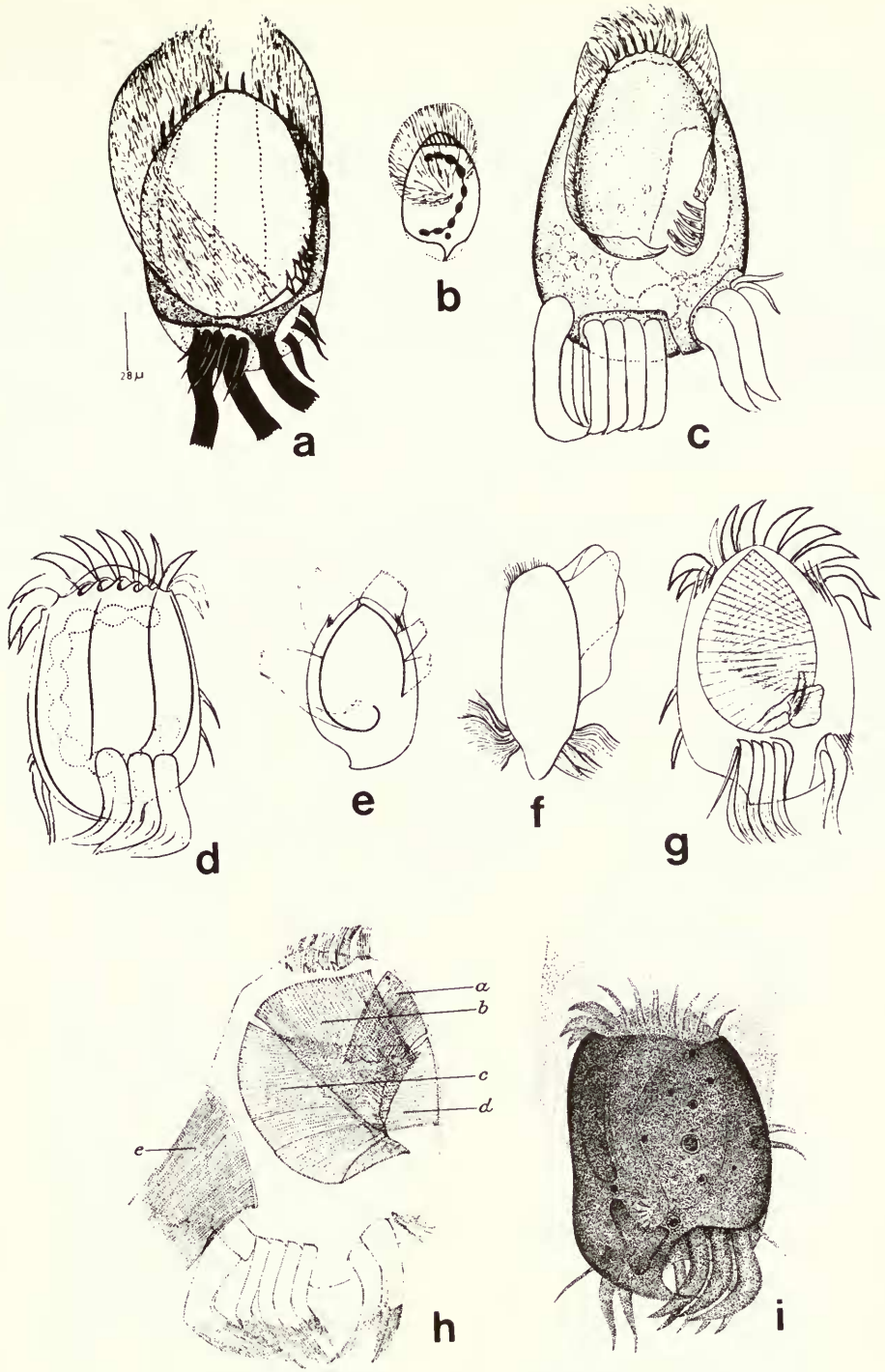

Fig. 29 *Uronychia transfuga*: (a, b) ventral surface and nuclei, after Kattar, 1970; (c) ventral surface, after Fenchel, 1965 (called *U. bivalvorum*); (d–g) ventral surface, dorsal surface showing nucleus, ventral view and lateral view of peristomial membranes, after Buddenbrock, 1920 (called *U. heinrothi*); (h) ventral surface, after Bullington, 1940 (called *U. heinrothi*); (i) dorsal surface, after Taylor, 1928 (called *U. uncinata*).

DESCRIPTION (Figs 27, 28 & 29). This is a cosmopolitan species. The oval shaped body is variable in size (50–260 μm long), its dorsal surface is arched and may be smooth or with 3–4 ridges. At the posterior right there are the 3 characteristically sickle-shaped right caudal cirri. The large peristome and two posterior cavities occupy most of the ventral surface. Prominent adoral membranelles are situated along the anterior edge of the body and these emerge dorsally. At the posterior left of the peristome, there are 4–5 paroral membranelles lying in a pocket-like invagination. Large undulating membranes border two sides of the peristome. There are 4–5 large transverse cirri implanted in the larger posterior cavity on the right, sometimes with 1 or 2 satellite cirri. In the posterior left cavity there are 2 large marginal cirri sometimes accompanied by a few, usually 2, small cirri or cilia. The macronucleus varies from being a moniliform (5–13 segments) C-shape at resting stage, to being 2 irregular masses immediately after cell division. The silver-line system consists of 3–5 dorsolateral kineties. It has been observed in the mantle cavities of the lamellibranch molluscs *Thyasira flexuosa* and *T. sarsi*.

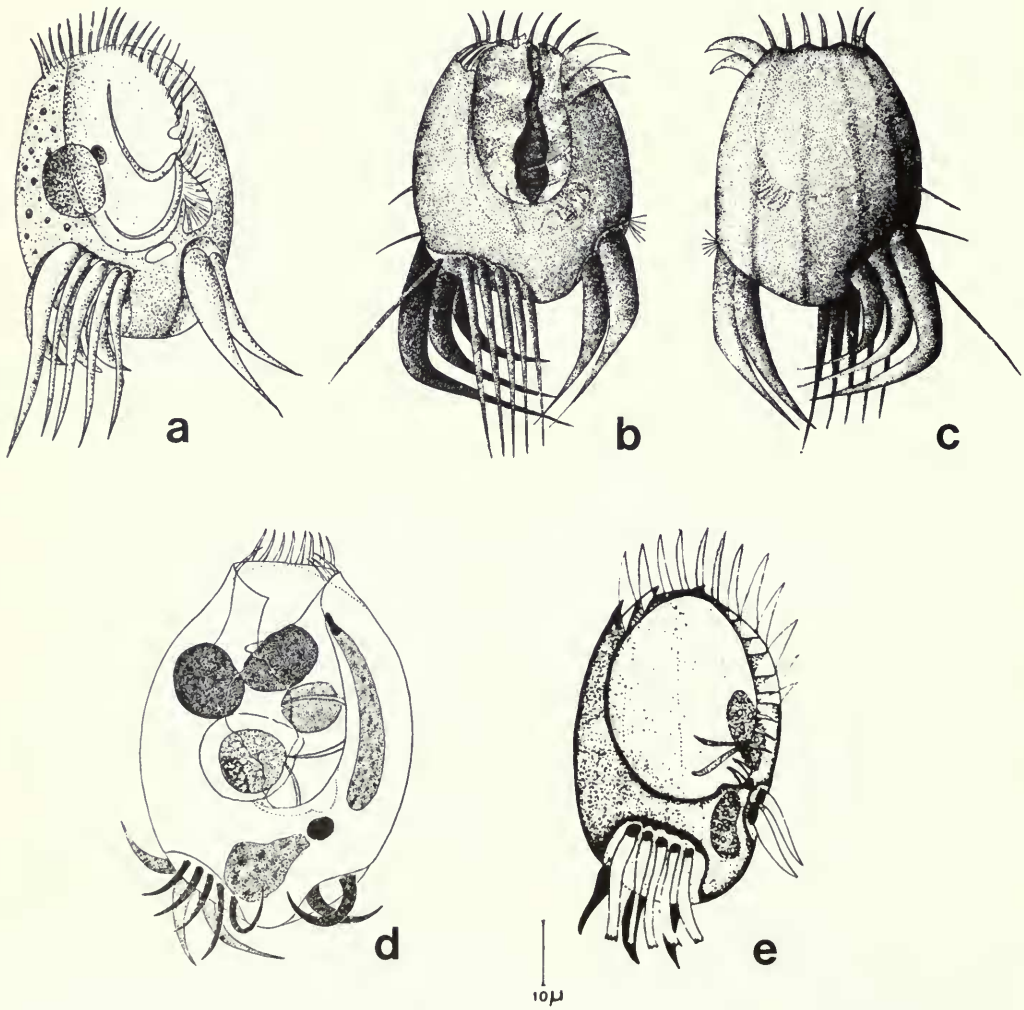

Fig. 30 *Uronychia setigera*: (a) after Calkins, 1902; (b–d) after Young, 1922; (e) after Kattar, 1970.

NOTES. Stein (1859*a*, *b*) established the genus *Uronychia* and redescribed *U.* (*Trichoda*) *transfuga* Muller as the type species. *U. transfuga* has since been identified by many workers from various localities (see Hartwig 1973, 1974). As discussed earlier *U. heinrothi*, *U. uncinata* and *U. bivalvorum* were established on characters that are now known to be variable and unreliable. These three species are here regarded as synonyms of the type species until more convincing data become available.

Uronychia setigera Calkins, 1902

DESCRIPTION (Fig. 30). This is the smallest (40–50 μm long) species yet described. The dorsal surface is arched and is sculptured longitudinally by 3–4 ridges. There are 2–3 flagella-like cirri in the large peristome and there are about 4 paroral membranelles. Wide undulating membranes lie on each side of the peristome. There are 3 curved right caudal cirri attached dorsally and a long thin satellite cirrus has been observed. In the two ventral cavities there are 4–5 transverse cirri and 2 large left marginal cirri. The macronucleus is usually in 2 band-like parts with a micronucleus between them but a single spherical macronucleus has also been observed in this species. There are 5 dorsolateral kineties.

NOTES. This species is characterised by the presence of flagella-like cirri extending from the posterior left margin into the peristome (Calkins, 1902). This author further distinguished it from the type species by its single ovoid macronucleus; however later authors (Young, 1922; Kattar, 1970) reported two macronuclei. Kattar (1970) impregnated the cell with protargol but failed to clearly illustrate the silver-line system.

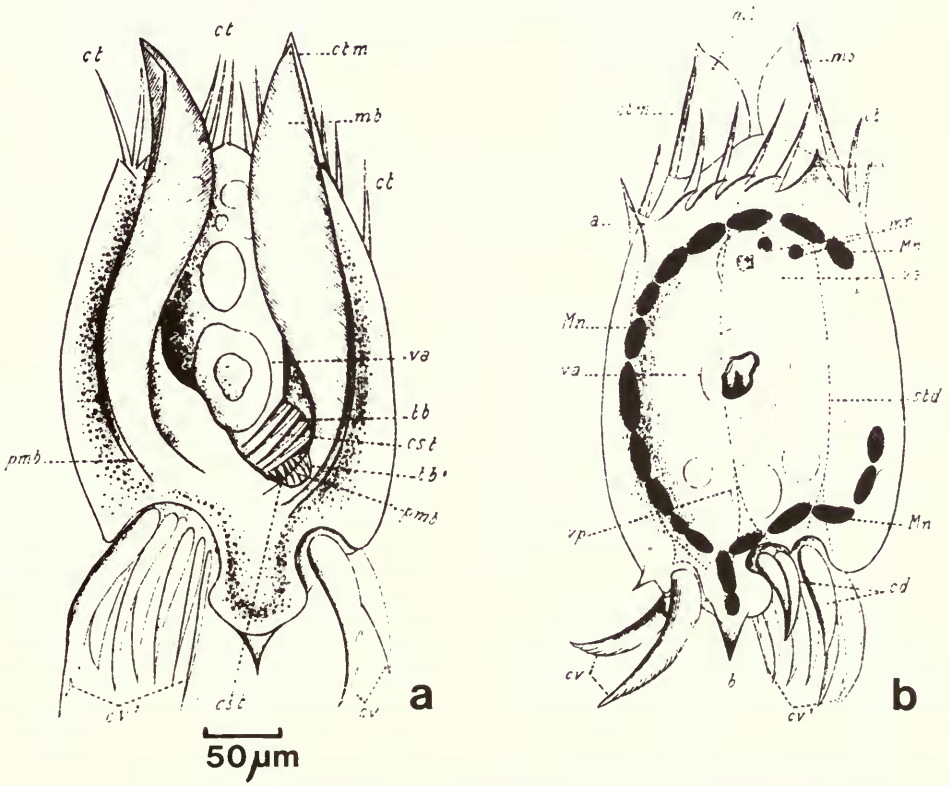

Fig. 31 *Uronychia magna*, after Pierantoni, 1909; (a) ventral surface; (b) dorsal surface.

Uronychia magna Pierantoni, 1909

DESCRIPTION (Fig. 31). This is the largest species yet recorded (450 μm long). The body shape is approximately oval in outline but is ornamented at either end. The anterior dorsal edge is serrated and there are two short spines on the posterior left dorsal border. The dorsal surface is longitudinally striated. The peristome is extensive, occupying most of the ventral surface. The AZM is located anteriorly in a posterior pocket in the peristome. There are two large undulating membranes, one on each side of the peristome. There are 6 transverse, 2 left marginal and 3 right caudal cirri. The macronucleus is in many pieces forming a string of beads which follow the curve of the left side of the body so that it is C-shaped. Anteriorly there are 2 micronuclei.

NOTE. This species has apparently been described on a single occasion.

Uronychia binucleata Young, 1922

DESCRIPTION (Fig. 32). *Uronychia binucleata* is 60–80 μm long. The dorsal surface is arched

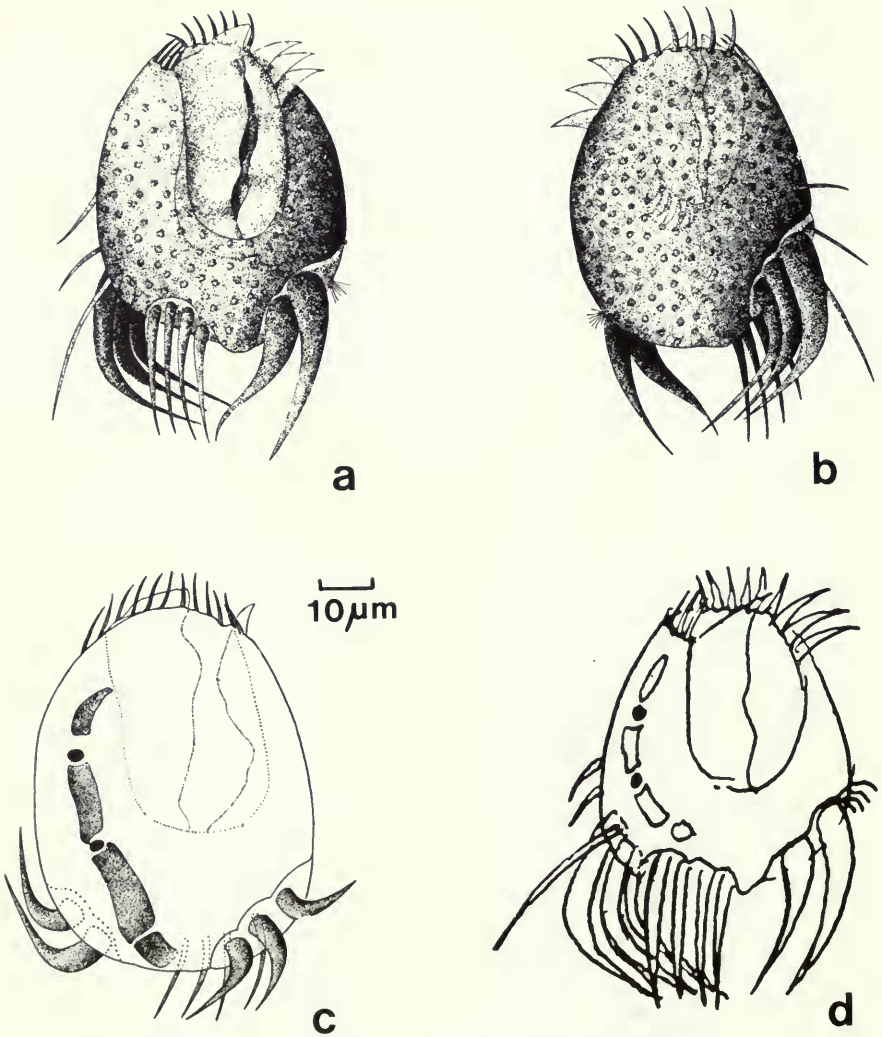

Fig. 32 *Uronychia binucleata*: (a–c) ventral surface, dorsal surface and nuclear features, after Young, 1922; (d) after Kahl, 1932.

and decorated with many small pits. The peristome is bordered on either side by a large undulating membrane and at the anterior left there are 3 delicate sickle-shaped membranelles. About 4 paroral membranelles lie in the 'buccal' pocket. There is a long slender cirrus accompanying the 3 curved right caudal cirri, 4 transverse, 2 left marginal and 2 right marginal cirri. The macronucleus is in 3–5 fragments and 2 micronuclei.

NOTES. Young (1922) established this species which he showed to be almost identical to *U. setigera* in his comparative study. He distinguished his species by the absence of peristomial cirri, the presence of 4 or less transverse cirri, and the presence of a slender right caudal cirrus in addition to the two micronuclei. Although Young (1922) described a satellite cirrus in *U. setigera* which he considered to be significant, curiously he failed to mention it in *U. binucleata* even though he illustrated it. Here the presence of two micronuclei is used to characterise the species: should future studies show that the number of micronuclei to be variable, then it would become synonymous with *U. transfuga*.

Genus ***CERTESIA*** Fabre-Domergue, 1885

Introduction

Fabre-Domergue (1885) described an organism that was very similar to *Euplotes* except that it had a row of left marginal cirri, no caudal cirri and the macronucleus was in four parts. In his view this was sufficient to create the new genus *Certesia* although later both Bütschli (1889) and Sauerbrey (1928) considered it to be a subgenus of *Euplotes*. Since the description of the type species, *Certesia quadrinucleata* Fabre-Domergue, 1885, only one other species, *Certesia ovata* Vacelet, 1960, has been described. Vacelet (1960) distinguished it from the type species on account of its smaller size, its more oval shape and its two curved left transverse cirri. Here, these differences are not considered to be sufficient to treat *C. ovata* as a separate species.

Diagnosis of *Certesia*

Oval marine hypotrichs with an anterior nose-like projection on the right anterior body edge. There is a conspicuous AZM which extends a third to halfway down the left side of the body. There are 11–13 frontoventral, 5 large transverse, and a variable number (6–11) of left marginal cirri. There are no caudal cirri. Macronucleus in several parts. Single species genus.

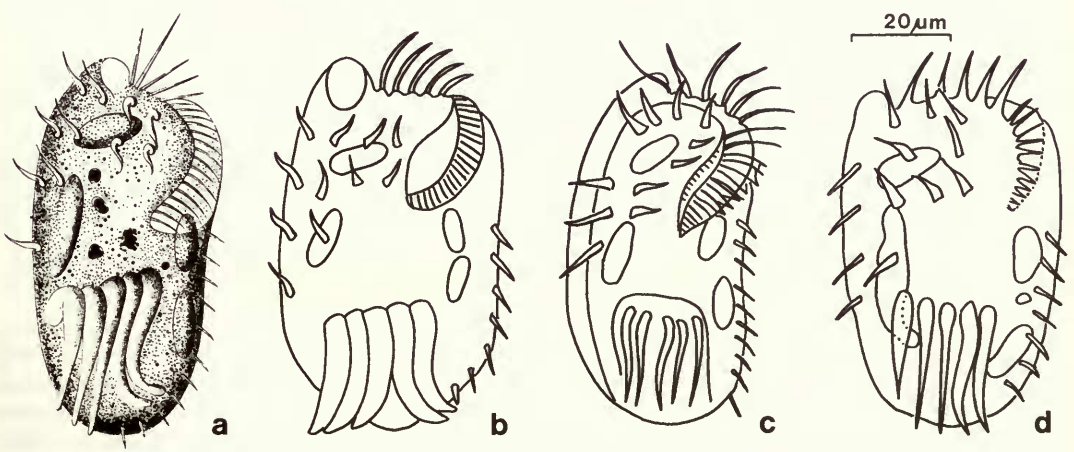

Fig. 33 *Certesia quadrinucleata*: (a) after Fabre-Domergue, 1885; (b) after Sauerbrey, 1928; (c) after Kahl, 1932; (d, e) after Vacelet, 1960 (called *C. ovata*).

Species description

Certesia quadrinucleata Fabre-Domergue, 1885

Certesia ovata Vacelet, 1960

DESCRIPTION (Fig. 33). *Certesia quadrinucleata* is a medium sized (75–80 μm long), oval, rigid and colourless marine hypotrich. The dorsal surface is arched and smooth: the ventral surface flat. The right body border is convex and the left may be slightly concave. There is a distinct nose-like projection on the right of the extreme anterior body edge. The peristome is a third to a half of the body length. The AZM consists of about 5 large membranelles along the anterior border and 15–20 smaller ones along the left edge of the peristome. There are 11–13 frontoventral cirri, 5 large transverse cirri, a row of 6–11 left marginal cirri but no caudal cirri. Four ovoid macronuclei are located in pairs, one pair on the right anterior and one pair on the left below the AZM.

Genus ***GASTROCIRRHUS*** Lepsi, 1928

Introduction

Lepsi (1928) created the genus *Gastrocirrhus* and stated that the type species *Gastrocirrhus intermedius* Lepsi, 1928 possessed characters that were intermediate between the oligotrichs and the hypotrichs. The organism had ventral cirri arranged in groups like those of hypotrichs, but its large anterior funnel-shaped peristome and spiral AZM were more like those of oligotrich genera such as *Stentor*. Kahl (1932) thought that the organism was probably a piece of a fragmented *Oxytricha*, but soon after Bullington (1940) established another species *Gastrocirrhus stentoreus* Bullington, 1940. This has been followed by several other species descriptions.

The six cirri along the right side of *G. intermedius* are here interpreted to be frontoventrals and the remaining ten cirri are called caudals. Bullington (1940) recorded the presence of four marginals, four ventral and two oral/anterior cirri on *G. stentoreus*. These are considered to be frontoventral cirri so that this species may be diagnosed by the presence of only five caudal cirri. In *Gastrocirrhus adhaerens* Fauré-Fremiet, 1954, there are 16 cirri arranged in two rows on the right of the peristome, and 12 in a semi-circle at the posterior. Here, these are interpreted to be frontoventral and caudal cirri respectively. *Gastrocirrhus trichocystus* Ito, 1958 has 18 frontoventral and 13 caudal cirri arranged similarly to those in *G. adhaerens* but the species is characterised by the presence of zones of trichocysts (mucocysts?) on the dorsal and ventral surfaces.

Fauré-Fremiet (1961) created the family Gastrocirrhidae and included the single species genus *Cirrhogaster* Ozaki & Yagui, 1942 in the family. The type species, *Cirrhogaster monilifer* Ozaki & Yagui, 1942 is similar to *G. adhaerens*, but the former species has 10 rather than 16 frontoventral cirri. Dragesco (1965) suggested that these two species were synonymous but here, although *C. monilifer* is considered to be a species of *Gastrocirrhus* it is not considered to be a synonym of *G. adhaerens*.

Diagnosis of *Gastrocirrhus*

Marine hypotrichs that may be dorsoventrally flattened or cup-shaped. There is a large anterior funnel-shaped peristome which opens both anteriorly and ventrally. A well developed AZM borders the C-shaped anterior body edge and winds anti-clockwise down the left of the peristome. There are 5–18 frontoventral cirri, usually arranged in two oblique rows on the right of the peristome: 5–13 caudal cirri along the posterior pole of the body which in some species curve forwards ventrally on the left to give the appearance of transverse cirri. Macronucleus may be oval or moniliform in 11–15 pieces.

Key to the species of *Gastrocirrhus*

1 With 10 frontoventral cirri 4
With 6, or more than 10 frontoventral cirri 2
2 With 6 frontoventral cirri . . . . . ***G. intermedius***
With more than 10 frontoventral cirri 3
3 With 16 frontoventral cirri and 12 thigmotactic caudal cirri, without 'trichocyst' zones ***G. adhaerens***
With 18 frontoventral cirri, 13 caudal cirri and with dorsal and ventral zones of 'trichocysts' ***G. trichocystus***
4 With 5 caudal cirri . . . . . ***G. stentoreus***
With 12–13 caudal cirri . . . . . ***G. monilifer***

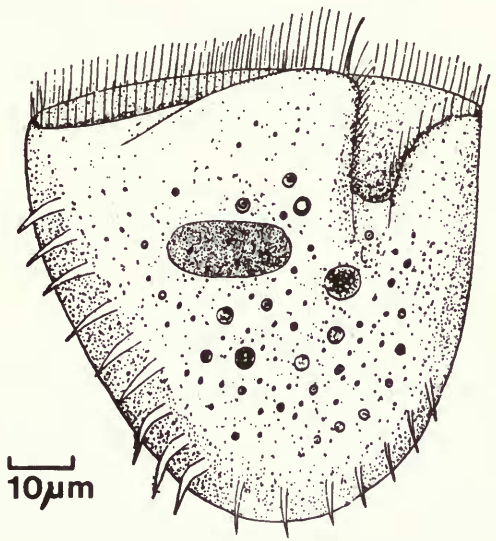

Fig. 34 *Gastrocirrhus intermedius*, after Lepşi, 1928.

Species descriptions

Gastrocirrhus intermedius Lepsi, 1928

DESCRIPTION (Fig. 34). This species is a dorsoventrally flattened cup-shape, approximately 70 μm long. The well developed AZM borders the anterior funnel-shaped peristome. There are 16 cirri in three distinct groups. Near the right body margin there are 6 frontoventral cirri. The caudals are situated along the posterior pole, comprised of a group of 3 sickle-shaped cirri, rather like the right caudal cirri in *Diophrys*, and 7 others to their left which are smaller and straighter. The macronucleus is oval.

NOTES. There is only a single description of this, the type species of the genus. The observations of Lepsi (1928) appear to have been made exclusively on living specimens. The arrangement of the cirri and nuclear features do not appear to be as typical as those of the species described later.

Gastrocirrhus stentoreus Bullington, 1940

DESCRIPTION (Fig. 35). *Gastrocirrhus stentoreus* is a medium sized (100 μm long, 70–80 μm wide) perfectly cup-shaped species. The large funnel-shaped peristome has a ventral, elongate opening about two-thirds of the body length and is bordered by a prominent AZM. There are 11 frontoventral cirri on the right of the peristome in groups of two, four and five cirri. At the posterior right margin, there are 5 sickle-shaped caudal cirri.

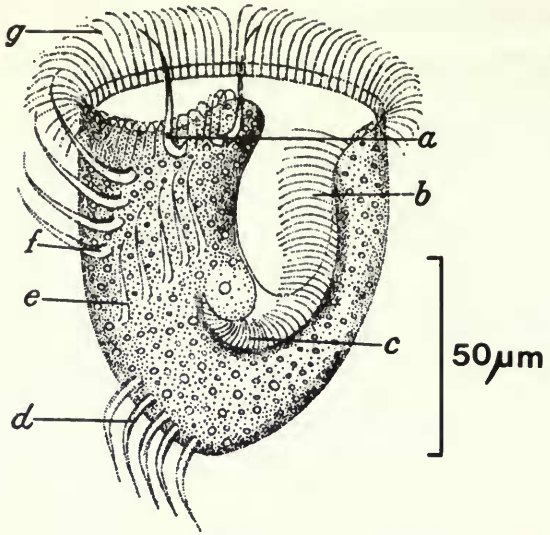

Fig. 35 *Gastrocirrhus stentoreus*, after Bullington, 1940.

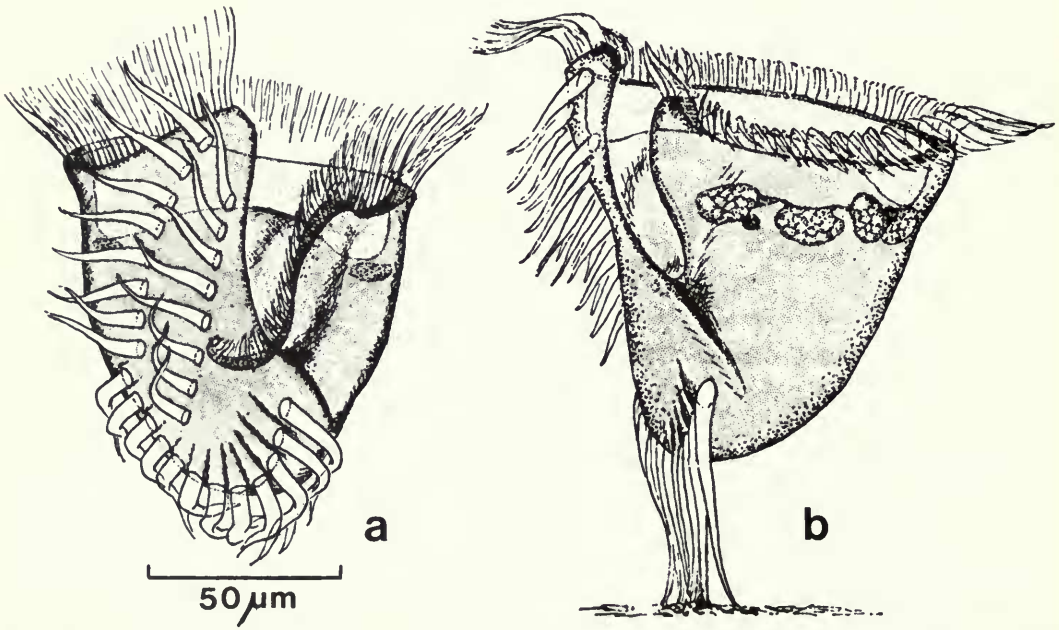

Fig. 36 *Gastrocirrhus adhaerens*: (a) ventral surface; (b) attached to substratum showing nuclei. Both after Fauré-Fremiet, 1954.

Gastrocirrhus adhaerens Fauré-Fremiet, 1954

DESCRIPTION (Fig. 36). This is a medium sized (100 μm long), typically cup-shaped species. The peristome diameter is slightly less than the body length. The AZM, which winds around the anterior of the cell and down the left side of the peristome, consists of about 150 membranelles. The species is characterised by its 12 very long thigmotactic caudal cirri along the posterior border of the cell which can be retracted when not attached to a substratum. There are 16 frontoventral cirri arranged in two rows of 8 cirri on the right of the

peristome. The moniliform macronucleus is composed of about 12 pieces: 3–5 micronuclei have been observed.

Gastrocirrhus monilifer n. comb.

Cirrhogaster monilifer Ozaki & Yagui, 1942

DESCRIPTION (Fig. 37). *Gastrocirrhus monilifer* is 95–105 μm long, 75–90 μm wide and cup-shaped. The ventral opening into the large funnel-shaped peristome is about a half the body length. The 10 frontoventral cirri, arranged in two rows, are restricted to the small area on the right of the peristome. There are 12 long caudal cirri. The moniliform macronucleus consists of 11–15 pieces and there are 8 micronuclei scattered along its length.

NOTES. Dragesco (1965) suggested that this species should be a synonym of *G. adhaerens*. Here it is considered to be a separate species until further information concerning the variability in numbers of frontoventral cirri become available.

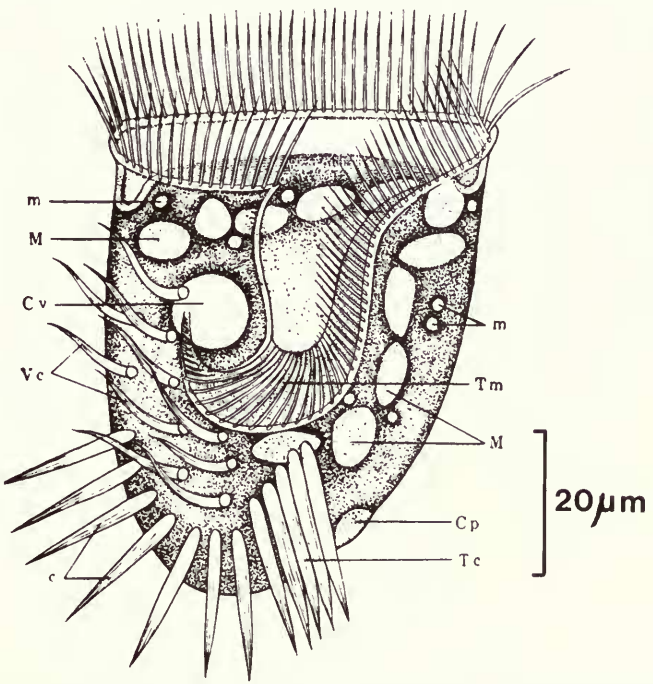

Fig. 37 *Gastrocirrhus monilifer*, after Ozaki & Yagui, 1942 (called *Cirrhogaster monilifer*).

Gastrocirrhus trichcystus Ito, 1958

DESCRIPTION (Fig. 38). *Gastrocirrhus trichocystus* is 90–103 μm long, 82–90 μm wide and cup-shaped. The ventral surface becomes flattened when starved. The large peristome is bordered by numerous long adoral membranelles. There are 18 frontoventral and 13 caudal cirri separated by longitudinal ridges on the ventral surface. The sickle-shaped macronucleus is moniliform with 10–12 pieces. There are usually 8 micronuclei. The species is characterised by bands of 'trichocysts' (mucocysts?) along the anterior and right margin of the dorsal surface, also they are found along the left margin and at the anterior right on the ventral surface.

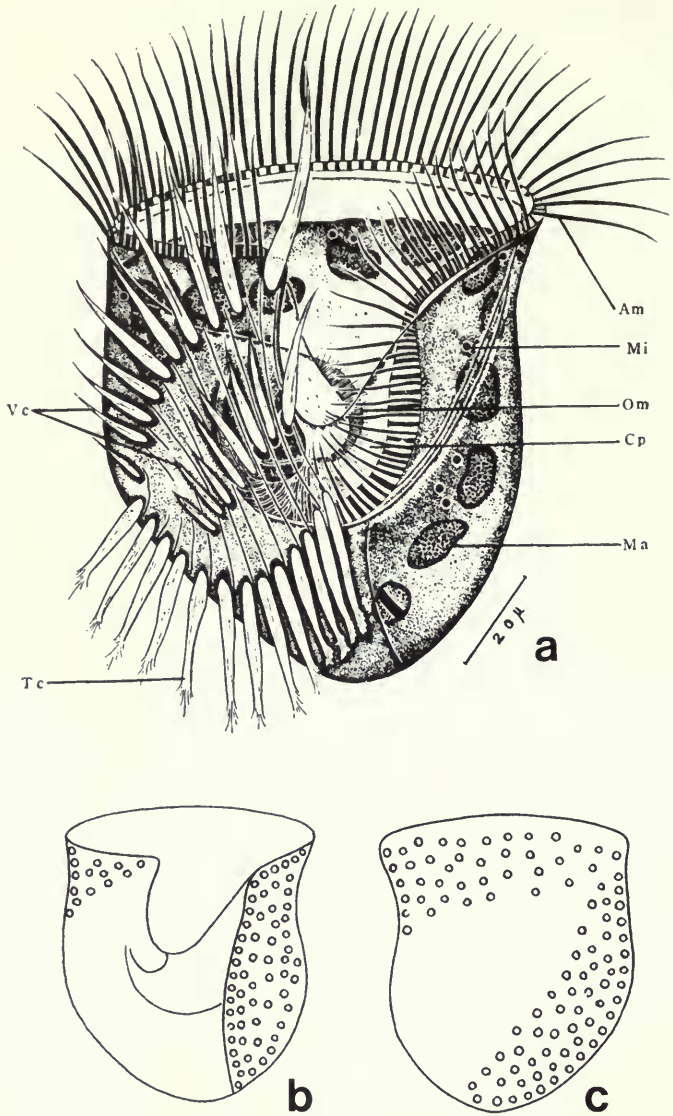

Fig. 38 *Gastrocirrhus trichocystus*, after Ito, 1958: (a) ventral surface; (b, c) ventral and dorsal surfaces showing trichocyst distribution.

Genus ***EUPLOTASPIS*** Chatton & Séguéla, 1936

Introduction

Chatton & Séguéla (1936) described a *Euplotes*-like hypotrich found in the branchial cavity of the sea squirt, *Ciona intestinalis*. They noted that the organisms were never observed on or around their host and they did not survive without their host for more than 36 hours in a medium which had been used successfully for the culture of many marine *Euplotes*.

This species was found to have many characters similar to those of *Euplotes* but Chatton & Séguéla (1936) noted that its body shape and very thick short cirri were more like those of *Aspidisca*. Furthermore, the AZM was entirely ventral so that it did not border the anterior dorsal surface as in *Euplotes*, and four of the frontoventral cirri were split into two parts which is a distinctive feature. Corliss (1961) placed this genus along with *Paraeuplotes* in the family Paraeuplotidae but later (Corliss, 1977) he transferred it to the family Aspidiscidae.

Diagnosis of *Euplotaspis*

Marine oval hypotrichs living in sea squirts. There is a prominent AZM restricted to the ventral surface. There are 9 frontoventral, 5 transverse and 3–4 caudal cirri. The four frontoventral cirri towards the right body border are split longitudinally into two parts. Macronucleus C-shaped. The dorsal argyrome is like that of *Euplotes vannus* (see Curds, 1975).

Species description

Euplotaspis cionaecola Chatton & Séguéla, 1936

DESCRIPTION (Fig. 39). *Euplotaspis cionaecola* is a 60–70 μm long marine hypotrich found in

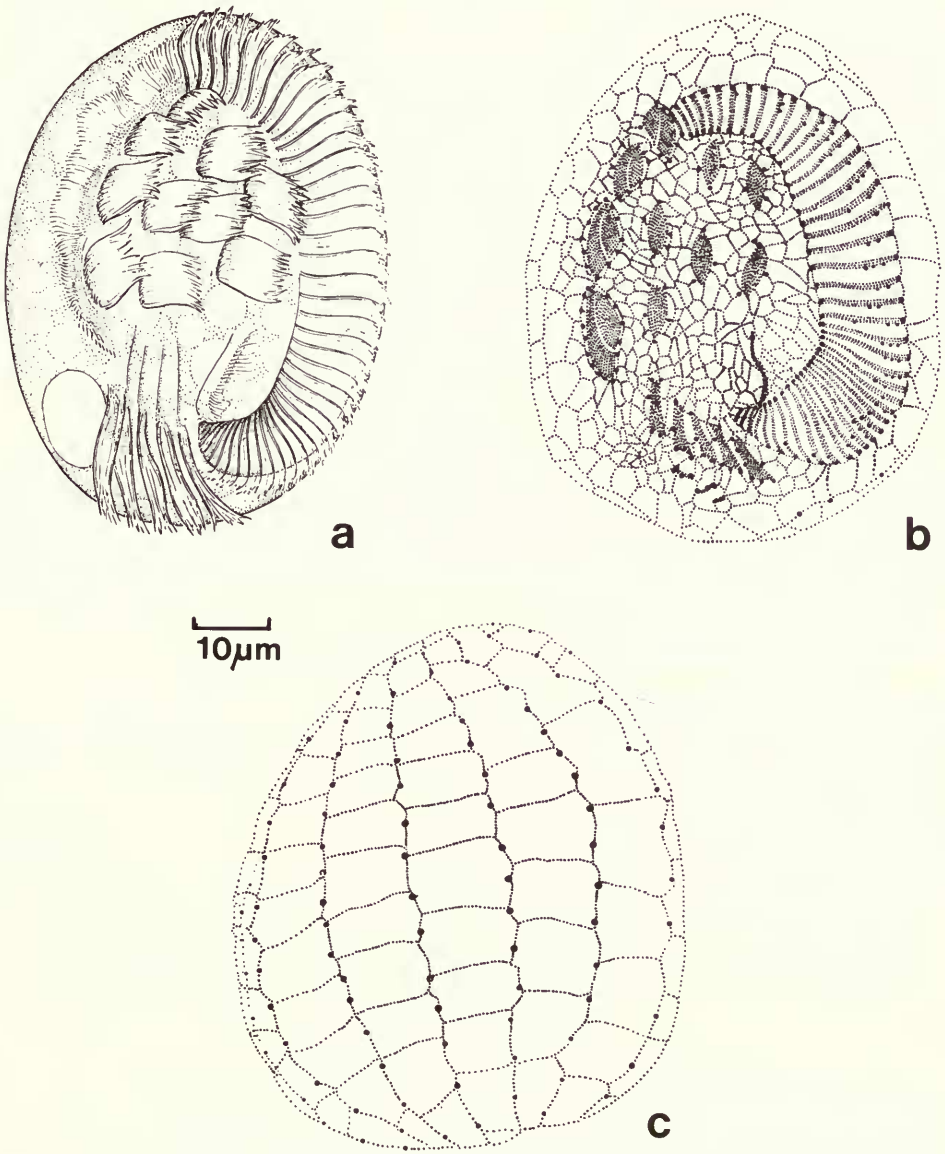

Fig. 39 *Euplotaspis cionaecola*, after Chatton & Séguéla, 1936: (a) ventral surface of living cell; (b, c) ventral and dorsal surfaces of silver-impregnated specimens.

the branchial cavity of *Ciona intestinalis*. The body outline is perfectly oval, convex dorsally and flattened or slightly concave ventrally. The AZM of about 50 membranelles, is a prominent band parallel to, and at a short distance from, the left body margin. There are 10 short, wide frontoventral cirri: the four on the right being split longitudinally. The 5 transverse cirri are separated by marked ridges on the ventral surface. The 3–4 caudal cirri are small and indistinct *in vivo* but can be seen in silver impregnated specimens. The dorsal silver-line system consists of 7–8 dorsal kineties, each carrying about 15 cilia, with simple cross-links between the kineties. The macronucleus is C-shaped and a single micronucleus has been observed at its posterior left.

Genus ***EUPLOTIDIUM*** Noland, 1937

Introduction

Noland (1937) described a hypotrich found in sponges from the Gulf of Mexico and stated that 'the organism differs from *Euplotes*, its nearest relative, in the absence of caudal cirri, and in the more cylindrical shape of the body'. Consequently, he erected the genus *Euplotidium* Noland, 1937 and called the organism *Euplotidium agitatum* Noland, 1937 because of its erratic movements. Ito (1958) also described a cylindrical *Euplotes*-like organism, but in this species there was one left caudal cirrus and more frontoventral and transverse cirri than in *E. agitatum*, this he called *Euplotidium itoi* Ito, 1958. A further species with different numbers of frontoventral and transverse cirri, *Euplotidium arenarium* Magagnini & Nobili, 1964, was later described and Borror (1972) transferred *Euplotes psammophilus* Vacelet, 1961 to the genus. More recently Hartwig (1980) added another species to the genus.

Diagnosis of *Euplotidium*

Small to large (65–200 μm long) marine hypotrichs. Outline shape slightly elongated oval. Rounded in cross-section, never dorsoventrally flattened. The peristome is a wide funnel-shape with a prominent AZM that borders both the anterior semi-circular body edge and the left margin of the peristome. There are 7–12 frontoventral, 5–6 transverse and, when present, a reduced number (1–2) of caudal cirri.

Key to the species of *Euplotidium*

1	With less than 10 frontoventral cirri	2
	With 10 or more frontoventral cirri	4
2	With 9 frontoventral cirri but without caudal cirri	***E. agitatum***
	With 7 frontoventral and 1 or 2 caudal cirri	3
3	With 1 caudal cirrus, macronucleus in many parts	***E. helgae***
	With 2 caudal cirri, macronucleus elongate	***E. psammophilus***
4	With 10 frontoventral and more than 1 caudal cirri	***E. arenarium***
	With 12 frontoventrals and 1 caudal cirrus	***E. itoi***

Species descriptions

Euplotidium agitatum Noland, 1937

Description (Fig. 40). This, the type species, is 65–95 μm long and its cylindrical body shape is most apparent when viewed from the anterior. There is a funnel-shaped peristome which is lined around its anterior rim and left side by a prominent AZM. There are approximately 40 membranelles on the anterior part and about the same number in the

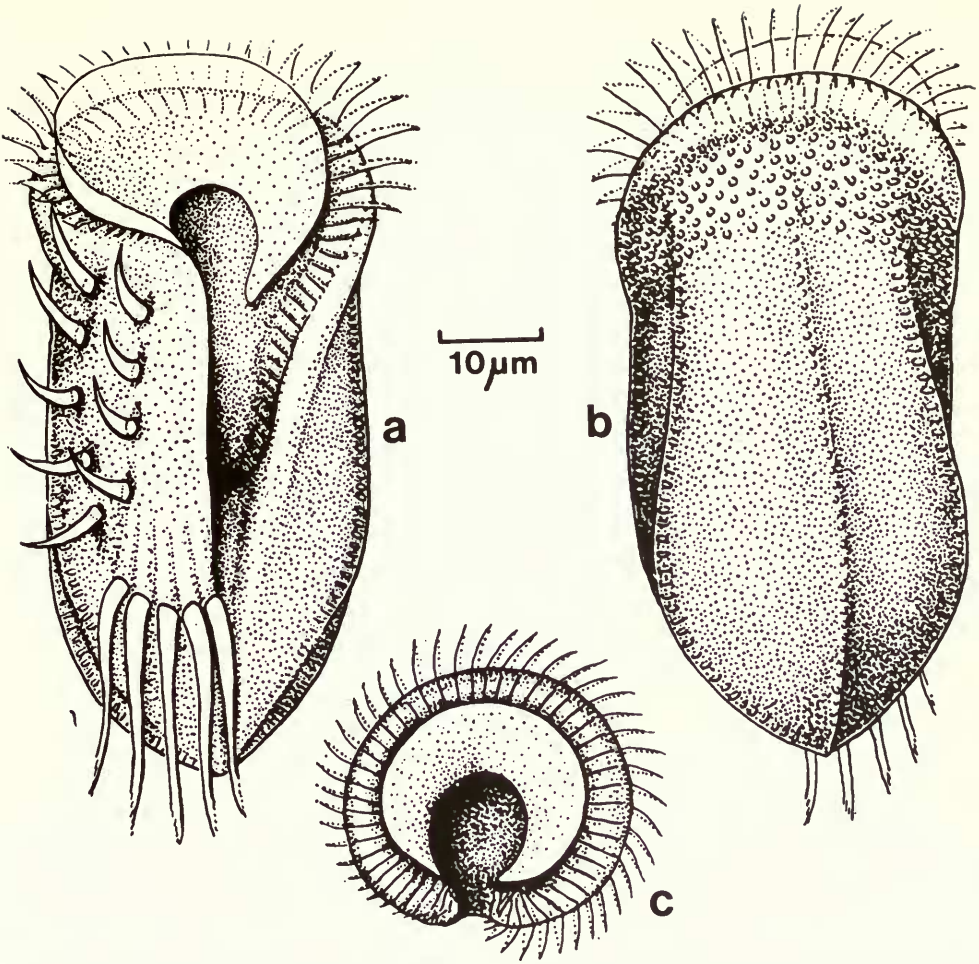

Fig. 40 *Euplotidium agitatum*, after Noland, 1937: (a) ventral surface; (b) dorsal surface; (c) view from anterior showing cylindrical body.

ventral part of the AZM. There are 9 frontoventral cirri, aligned in 2 rows, near the right body edge and 5 conspicuous transverse cirri but caudal cirri are not present.

NOTE. Originally isolated from water squeezed from sponges in the Gulf of Mexico.

Euplotidium itoi Ito, 1958

DESCRIPTION (Fig. 41). This is a medium sized (89–95 μm long), cylindrical hypotrich with a slightly flattened ventral surface. The AZM borders the anterior and left edges of the peristome forming a sigmoid shape. Nine of the 12 frontoventral cirri are in 2 oblique rows situated near the anterior right of the peristome while the other 3 are scattered along the right body edge. There are 6 large transverse cirri and a single small left caudal cirrus. The macronucleus is in 2 ribbon-like parts with 4 micronuclei.

NOTES. The position of the reorganisation band in Ito's (1958) diagram indicates that it could have been at some stage of division. Originally found in seaweed in the Inland Sea of Japan.

Euplotidium arenarium Magagnini & Nobili, 1964

DESCRIPTION (Fig. 42). This is a medium sized (71–120 μm long) oval species with a wide

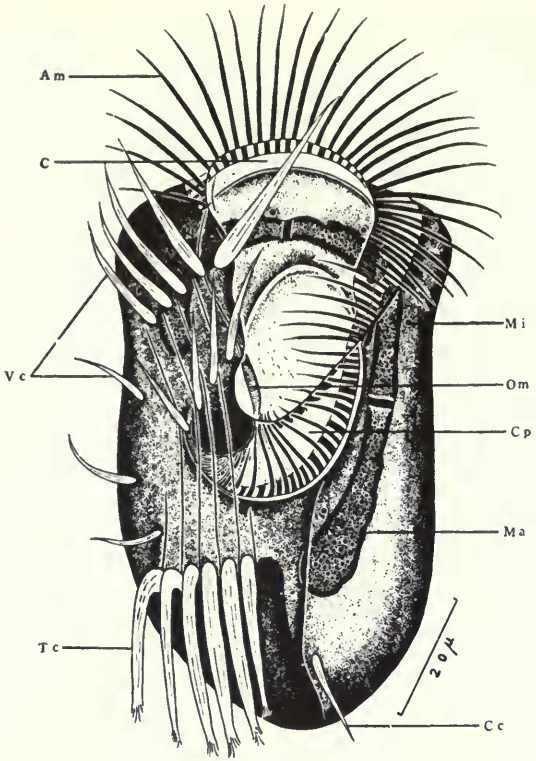

Fig. 41 *Euplotidium itoi*, after Ito, 1958.

triangular peristome. The AZM consists of about 75 membranelles and it extends around the anterior semi-circular rim of the peristome down to the left side. There are 10 frontoventrals, 5 transversals and a single left caudal cirrus. The transverse cirri are not conspicuous as in the other species of the genus and could be overlooked. The macronucleus is moniliform, in 5–10 pieces, and is curved towards the right. The silver-line system consists of 2 marginal kineties confluent posteriorly and there are dorsal and ventral mesh-like argyromes.

NOTE. Originally isolated from sand in the Gulf of Naples.

Euplotidium psammophilus (Vacelet, 1961) Borror, 1972

Euplotes psammophilus Vacelet, 1961

DESCRIPTION (Fig. 43). This is a large (125 μm long) species in which the wide peristome extends about two-thirds down the length of the body. There are 7 frontoventral cirri arranged in 2 groups on the right of the peristome. Three are closely packed together at the anterior and 4 are in a row behind them. The 5 transverse cirri are long and there are 2 caudal cirri. Vacelet (1961) also described the presence of a row of short cilia along the posterior right body edge. The elongated curved macronucleus is rod-like with an adjacent micronucleus.

NOTES. This was originally described as a species of *Euplotes*; Borror (1972) transferred it to *Euplotidium* on account of the shape of the body and peristome and because of the reduced number of caudal cirri.

Euplotidium helgae Hartwig, 1980

DESCRIPTION (Fig. 44). This is the largest (up to 200 μm long) of the species. The peristome

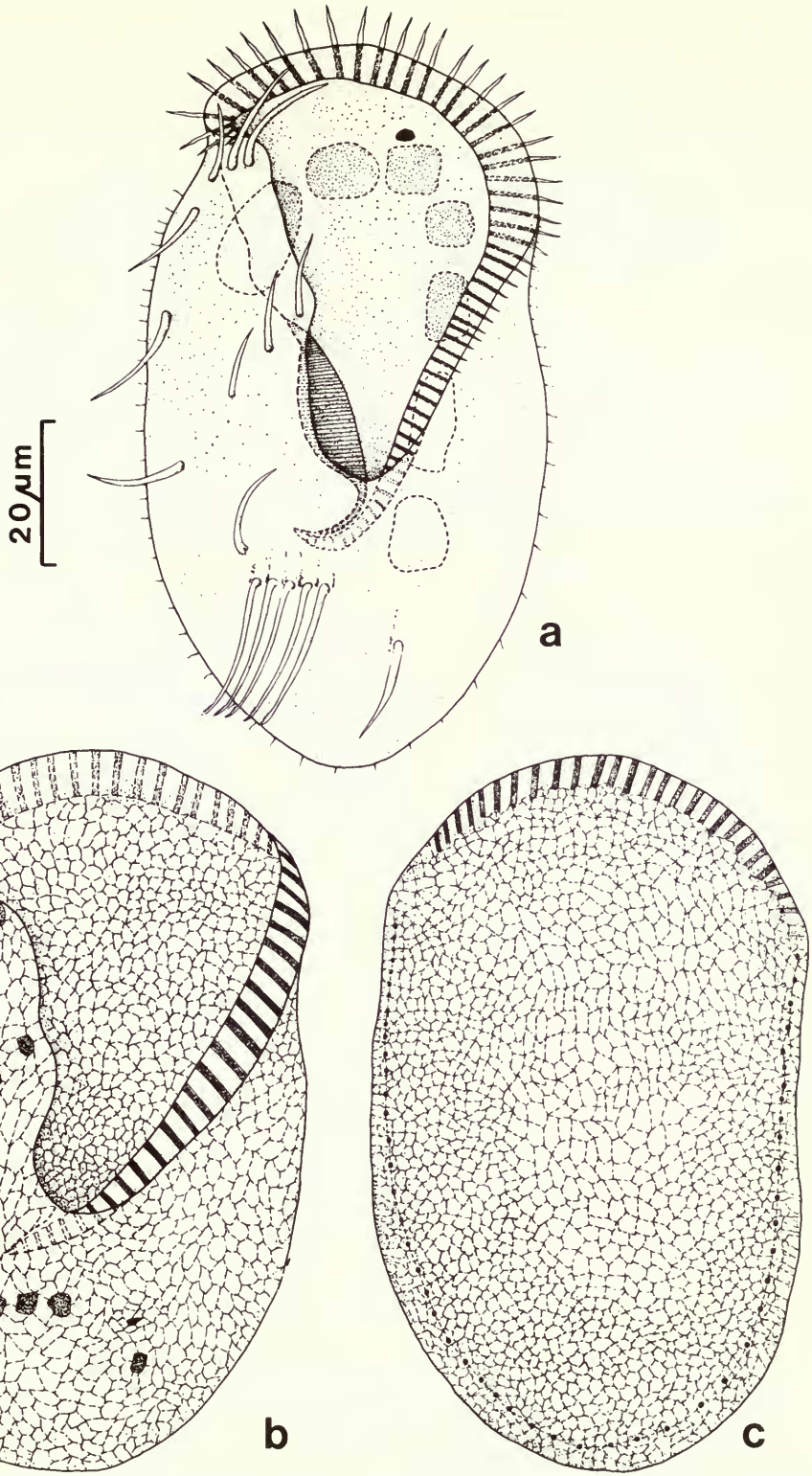

Fig. 42 *Euplotidium arenarium*, after Magagnini & Nobili, 1964; (a) ventral surface of living cell; (b, c) ventral and dorsal surfaces of silver-impregnated specimens; (d) stages in nuclear reorganisation.

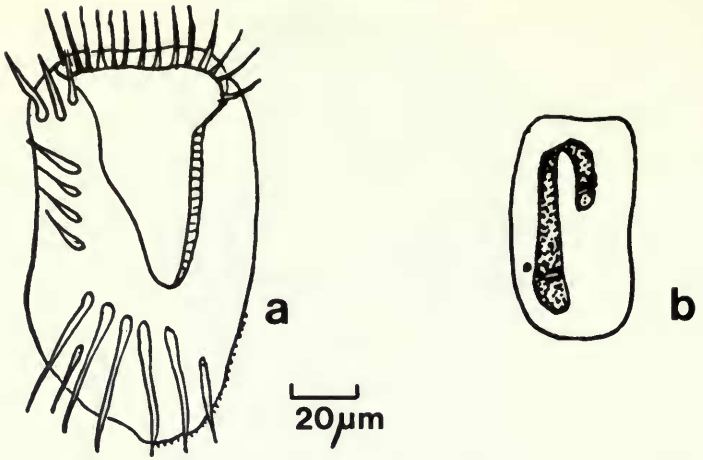

Fig. 43 *Euplotidium psammophilus*, after Vacelet, 1961 (called *Euplotes psammophilus*): (a) ventral surface; (b) nuclear apparatus.

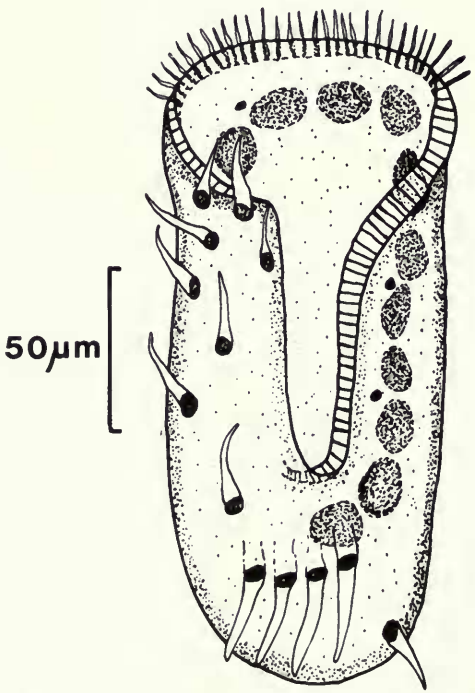

Fig. 44 *Euplotidium helgae*, after Hartwig, 1980.

extends about two-thirds down the body length. The original author (Hartwig, 1980) was not too sure about the cirral pattern and the interpretation used here is based on the assumption that there are 5 transverse and 7 frontoventral cirri rather than 4 transverse and 8 frontoventral cirri. There is a single caudal cirrus on the left and the frontoventrals are arranged in a single group on the right of the peristome. The macronucleus consists of 11 oval parts arranged in the shape of the letter C. There are several micronuclei.

NOTE. Originally found in sand in Bermuda.

Genus *PARAEUPLOTES* Wichterman, 1942

Introduction

Wichterman (1942) described a hypotrichous ciliate which he found in abundance on the coral *Eunicea crassa* in the Tortugas. The species resembled *Euplotes* in that it had a well developed AZM and a C-shaped macronucleus, but its rather peculiar ciliature bore no resemblance to that of *Euplotes*. He called the genus *Paraeuplotes* Wichterman, 1942 and placed it in a new family, the Paraeuplotidae Wichterman, 1942. Here, following Borror (1972) and Corliss (1977) the genus is provisionally included in the Euplotidae.

Diagnosis of *Paraeuplotes*

Discoid marine hypotrich with a well-developed AZM which originates on the dorsal surface and curves down three-quarters of the body length on the ventral surface. Undulating membrane absent. There are no marginal cirri but there is a small group of short caudal cirri. There is an extensive arc of transverse cirri parallel with the right body edge. Anteriorly, there is an arc of cilia parallel with the apical body edge and an isolated pair of cirri in the midventral position. The macronucleus is C-shaped. Contains numerous zooxanthellae.

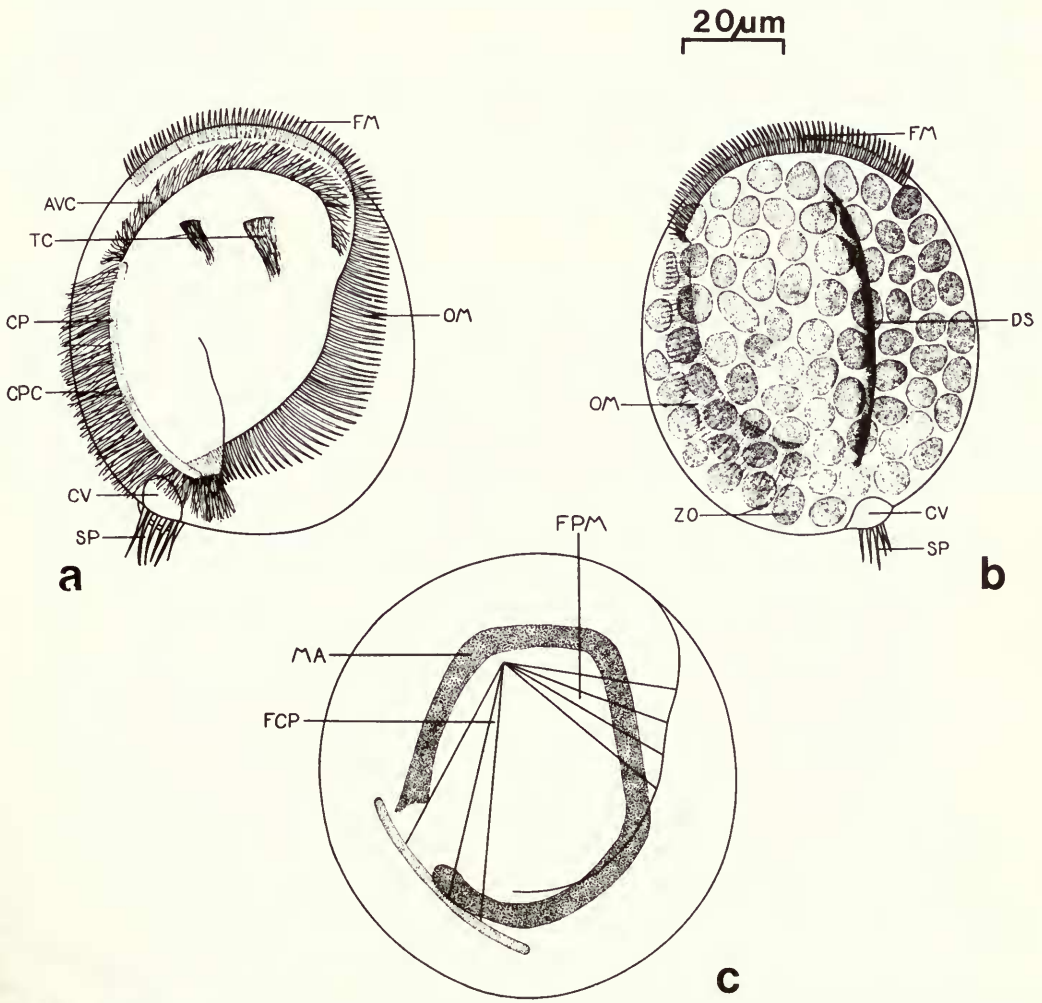

Fig. 45 *Paraeuplotes tortugensis*, after Wichterman, 1942: (a) ventral surface; (b) dorsal surface; (c) nucleus.

Species description

Paraeuplotes tortugensis Wichterman, 1942

DESCRIPTION (Fig. 45). Small to medium discoid species measuring on average 80 μm in diameter. The well-developed AZM forms a collar-like structure on the anterior dorsal surface which extends ventrally down about three-quarters of the body length. There is no undulating membrane present. Anteriorly there is an arc of cilia parallel with the body edge and a pair of isolated cirri lying in a midventral position. There is an extensive arc of transverse cirri parallel with the right body edge and a group of 5–6 short caudal cirri slightly to the right of the posterior body pole. The macronucleus is C-shaped. The cell is packed with numerous yellow-brown zooxanthellae.

NOTE. Originally isolated from the coral *Eunice crassa* in the Tortugas.

Genus *SWEDMARKIA* Dragesco, 1954

Introduction

Dragesco (1954, 1960, 1965) studied and described this genus over a period of several years. He (Dragesco, 1960, 1965) likened the genus to *Euplotidium* and *Gastrocirrhus* and considered it to be a possible evolutionary link between the Holostichidae Fauré-Fremiet, 1961 and the Euplotidae. Both Fauré-Fremiet (1961) and Corliss (1977) placed *Swedmarkia* in the family Gastrocirrhidae but it is here provisionally included in the Euplotidae.

Diagnosis of *Swedmarkia*

Medium sized (100–110 μm long) marine hypotrichs with conspicuous AZM arranged around a wide triangular peristome. There are two particularly long membranelles at the left of the apex of the peristome. A wide undulating membrane lies on the right of the peristome. There are many (54–58) cirri present with the following distribution. Numerous frontoventrals include a row along the right peristome edge, an apical group and an irregular midventral row. There are 5 large transverse and rows of right and left marginal cirri that are confluent posteriorly. The macronucleus is divided into numerous (about 100) portions and there are 5–9 micronuclei.

Species description

Swedmarkia arenicola Dragesco, 1954

DESCRIPTION (Fig. 46). This is a medium sized (100–110 μm long) marine hypotrich, similar in shape to *Euplotes*. The body is oval to triangular in shape and there is a large triangular peristome which extends down three-quarters of the body length where it occupies about half of the ventral surface. The AZM consists of 54–68 membranelles of which two, at the extreme left apex of the peristome, are particularly long. There is a wide undulating membrane on the right peristome border. The total of 54–58 cirri are arranged as follows, a row of frontoventral (peristomial) cirri is spaced evenly along the right peristomial edge. A group of 6 frontoventral cirri are situated around the extreme apex of the cell and there is an irregular row of 5 frontoventrals lying in the midventral position. Additionally, a short row of left marginal cirri is present with an irregularly spaced row of right marginals, of which the anterior half arise from the dorsal surface. The marginals are continuous along the posterior border. The macronucleus is divided into numerous (about 100) spherical pieces and there are 5–9 micronuclei. The three dorsal kineties bearing double cilia are illustrated in Fig. 46b.

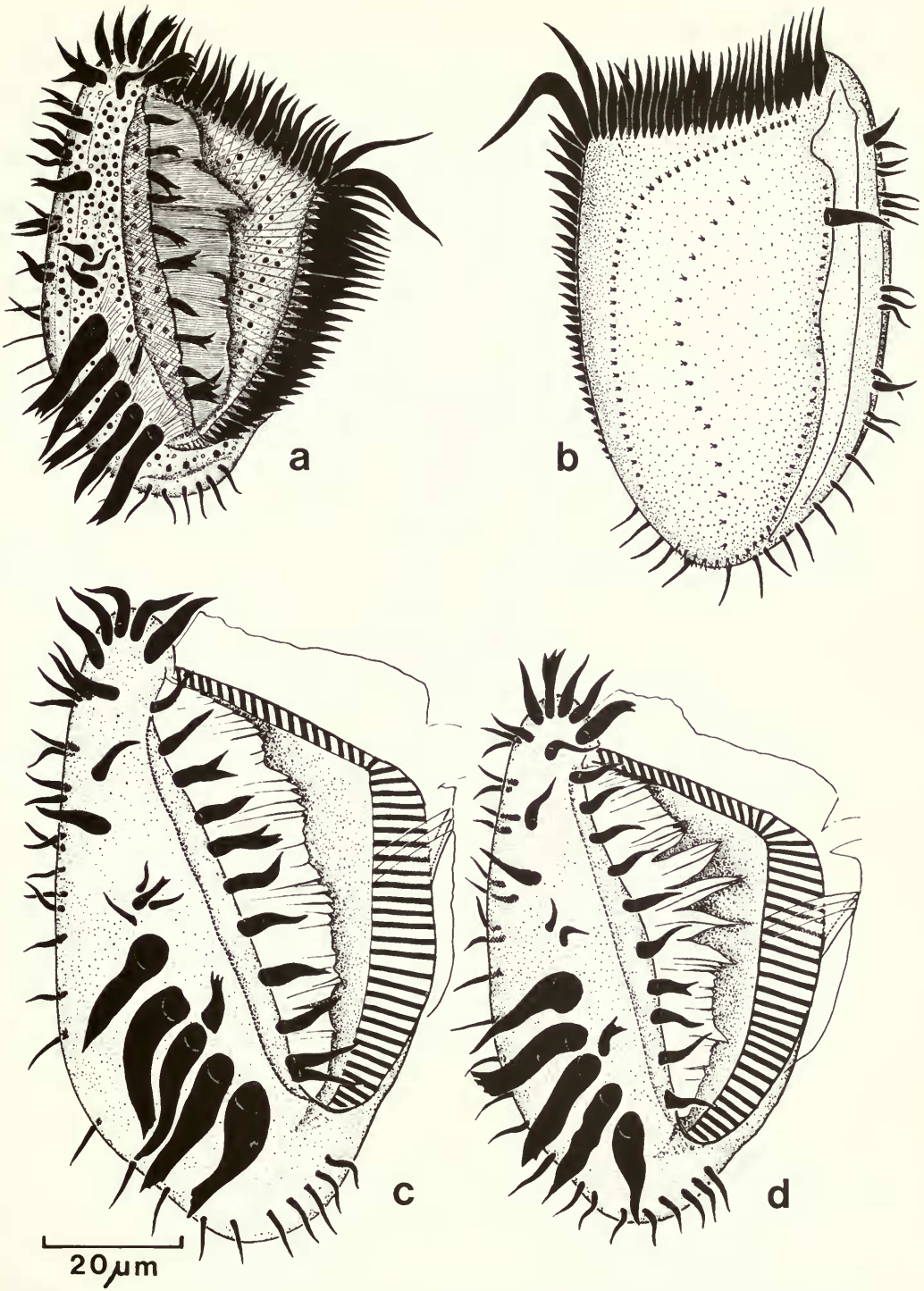

Fig. 46 *Swedmarkia arenicola*, after Dragesco, 1965: (a) ventral surface; (b) dorsal surface; (c, d) ventral surface showing variations in form, number and arrangement of certain cirri.

Genus *GRUBERELLA* (Gruber, 1884) Corliss, 1960

Stylocoma Gruber, 1884

Introduction

Gruber (1884) described the marine hypotrich *Stylocoma oviformis* Gruber, 1884 which Kahl (1932) redescribed and placed in the family Euplotidae. Soon after, another species, *Stylocoma adriatica* Kiesselbach, 1936, which lacked transverse cirri, was described. Corliss (1960) pointed out that the generic name was preoccupied by *Stylocoma* Lioy, 1864 a dipteran insect, and proposed that it should be replaced by *Gruberella* Corliss, 1960. Borror (1972) considered the genus to be of questionable status but Corliss (1977) included it as an *incertae sedis* in the Sporadotrichina. Here, the genus is provisionally included in the Euplotidae on account of its funnel-like peristome, which is reminiscent of *Gastrocirrhus*, and the arrangement of cirri which, although reduced, are more like those in the Euplotidae than in any other family of hypotrichs.

Diagnosis of *Gruberella*

Ovoid, marine hypotrichs, rounded in cross-section. There is a centrally placed funnel-shaped peristome bordered by a conspicuous AZM anteriorly and down the left side. Cirri reduced. Caudal cirri present, transverse cirri may or may not be present. Frontoventral and marginal cirri absent. Macronucleus in two parts.

Key to the species of *Gruberella*

1	With 6 caudal and 7 transverse cirri	***G. oviformis***
	With 6 caudal but without transverse cirri	***G. adriatica***

Species descriptions

Gruberella oviformis (Gruber, 1884) Corliss, 1960

Stylocoma oviformis Gruber, 1884

DESCRIPTION (Fig. 47). Ovoid marine hypotrich with wide, centrally placed, funnel-shaped peristome which has a slightly raised edge forming an anterior collar-like region. The

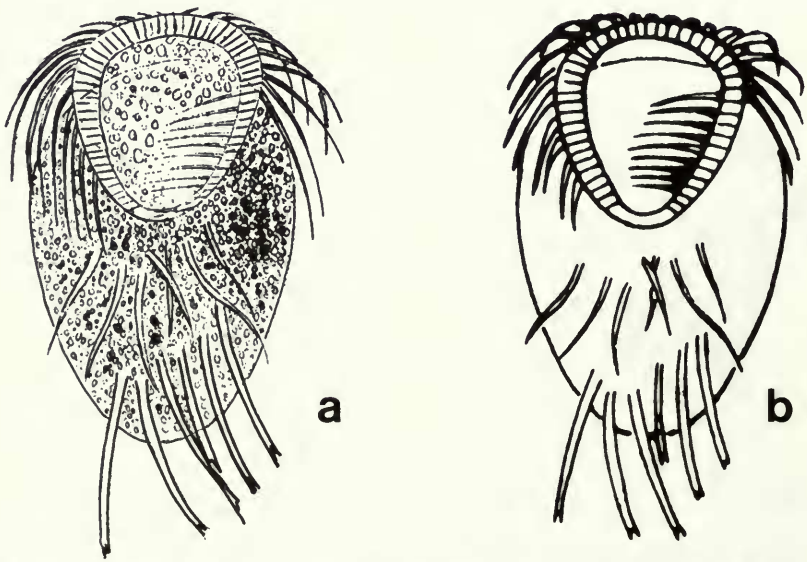

Fig. 47 *Gruberella oviformis*: (a) after Gruber, 1884; (b) after Kisselbach, 1936.

prominent AZM consisting of many large membranelles originates on the ventral surface on the right of the peristome and continues around the apex down the left side. There are only 2 groups of cirri, 7 transverse and 6 long caudal cirri. No frontoventral or marginal cirri are present. Shape of macronucleus unrecorded.

Gruberella adriatica (Kisselbach, 1936) Corliss, 1960

Stylocoma adriatica Kiesselbach, 1936

DESCRIPTION (Fig. 48). Medium sized (80 μm long) triangular shaped marine hypotrich with funnel-shaped, centrally positioned peristome. Prominent AZM borders the anterior and left peristomial edges. Cirri reduced to a single group of 6 long caudals. There are no transverse, frontoventral or marginal cirri present. Macronucleus divided into 2 ovoid pieces with a micronucleus between the pair.

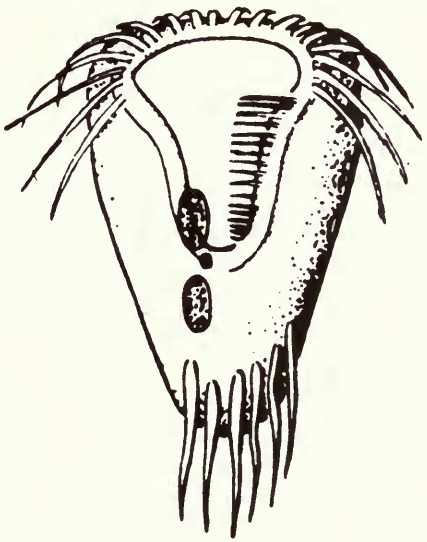

Fig. 48 *Gruberella adriatica*, after Kisselbach, 1936.

Genus ***CYATHAROIDES*** Tuffrau, 1975

Introduction

Tuffrau (1975) described a species from Antarctica which closely resembled *Euplotes* in certain respects but not in others. It is characterised by the presence of a row of 12 large right marginal cirri in addition to the usual frontoventral and transverse cirri. Furthermore, there is an extensive paroral membrane composed of a single kinety of long cilia which is unlike the undulating membrane of *Euplotes* and there is also endoral ciliature which is not found in *Euplotes*.

Diagnosis of *Cyatharoides*

Irregularly oval marine hypotrich with a very large peristomial funnel occupying much of the ventral surface onto which it opens. The peristome is surrounded by a collar-like swelling of the anterior left body edge, with a characteristic 'niche' or invagination of the right anterior peristome region. The AZM is composed of many membranelles lining the left peristomial border. On the right, at the bottom of the peristomial funnel there is a paroral membrane composed of a single kinety of long cilia and an arc of endoral cilia. There are 10 frontoventral, 5 transverse and a row of 12 right marginal cirri along the right body edge. Dorsally there are 12–26 kineties of cilia and the macronucleus is C-shaped.

Species description

Cyatharoides balechi Tuffrau, 1975

DESCRIPTION (Fig. 49). Irregularly oval, large (140–200 μm long) marine, planktonic hypotrich with a very large peristomial funnel opening over much of the ventral cell surface. Anteriorly the peristome is surrounded by a collar-like swollen ridge of the anterior left body edge, with a characteristic invagination of the peristome on the right anterior edge. The AZM is prominent and composed of many large membranelles. There are paroral and endoral membranes on the posterior right peristomial edge. With 10 frontoventral, 5 transverse and 12 right marginal cirri. Dorsal surface with 12–26 kineties of many cilia. Macronucleus large, open C-shaped.

NOTE. Originally isolated from plankton sample taken from Antarctic Ocean near base of Argentina by Prof. Balech.

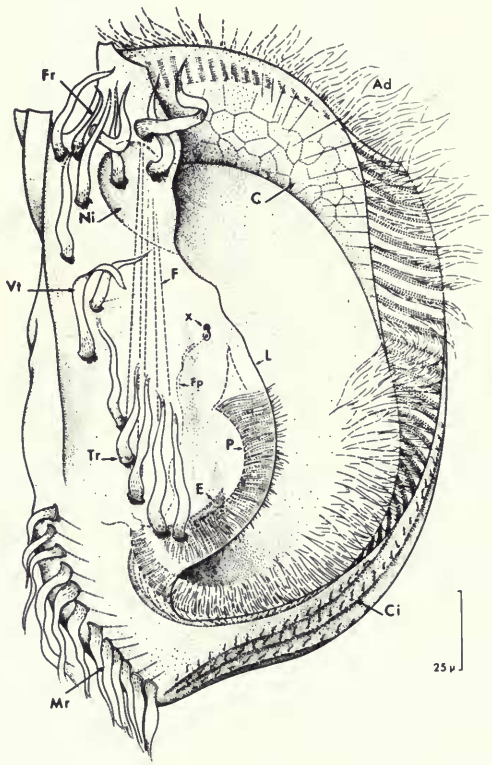

Fig. 49 *Cyatharoides balechi*, ventral surface, after Tuffrau, 1975.

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(Names given in roman refer to synonyms)